approach

OCTOBER 1966 THE NAVAL AVIATION SAFETY REVIEW

v.12
#4

The CURE for Pilot/LSO caused Carrier Landing Accidents

By LT Paul B. Austin

To: All Embarked Airwing Naval Aviators

Every pilot-caused carrier landing accident can be put into one of two categories—the pilot *did something he should not have,* or *failed to do something* he should have. Obviously, at this stage of hardware development the pilot is the only person capable of making a safe carrier landing. Sure, a good LSO can talk a pilot aboard if he has to but this procedure should be used only when all else has failed or the pilot is in real trouble. (More on this later).

Below you will find a list of rules. Fly religiously by them and *you* will never cause your own carrier landing accident. These rules are not listed in any particular order because if you break just one of them you are in serious trouble.

Rule 1. Start thinking about every approach *before* you actually begin the approach. Think about it in the holding pattern at night or on the downwind leg following a bolter or during the day before flight ops. Think positive. Be exacting. Go over in your mind how to make as perfect a start as possible. *Do this for every single landing.* Concentrate on the start position. Be right on angle of attack, altitude and lineup. Don't let the aircraft fly itself, be a pro and put the aircraft exactly where it should be.

Rule 2. Fly the ball all the way to touchdown. An amateur gives up on the ball in close and shifts his attention to the deck. *It takes a concerted, conscious effort to fly the ball all the way.* If you can not make this extra effort you shouldn't be making carrier landings.

Rule 3. Never spot the deck just because it's pitching a little, a lot or even if the ship appears to be coming out of the water. Fly the ball and listen to your LSO. *No matter how badly a deck is pitching there are frequent periods when it approaches a near steady state condition and this is the time to land.* However, as a pilot, you will not be able to predict these periods but your LSO will. So don't concern yourself with the conditions of deck movement. Your LSO is a better judge of this than you are and he will not let you land if the deck is not acceptable.

Rule 4. Never reduce power when approaching the ramp position. The tendency is to reduce too much power and end up with an excessive sink rate. If you use excessive power in close you can expect a waveoff or a bolter, neither one of which will do more than dent your pride. The professional says

"sorry about that, I'll work on it next pass." The amateur, if he is still able, makes his comments to the accident board or . . .

Rule 5. Never try to center a high ball in close. The last part of the glide slope is just too narrow to start the ball down and still be able to stop it before you make contact with the deck. If you stop the ball right where it is you'll get aboard! A low in the middle will normally give you a rising ball in close. Don't overcorrect. . .

Rule 6. Anytime you lose the ball after you are well into the approach, approximately halfway down the slope, take a waveoff. You are just too far from optimum glide slope to do little more than "salvage" the approach. You just made a mistake. Don't compound it. Mentally remind yourself to strive to do it correctly on the next pass.

Rule 7. Learn the proper corrections for optimum glide slope control. Know how to handle a high or low in the middle, a fast or slow, etc. This is so basic it shouldn't require mentioning but improper corrections still continue to kill pilots.

Rule 8. *Ball, Lineup, Angle-of-attack.* Keep your scan moving. If you concentrate on any one of them, the other two will break down. With the angle-of-attack (AOA) mounted on the glare shield, you can keep track of it peripherally as you look at the ball. You can't make corrections for glideslope, speed or lineup if you don't know where you are. Keep the scan going all the way.

Rule 9. Make small positive corrections immediately. Don't let things get out of hand before you decide to do something about it.

Right about now you are probably saying to yourself, "So what else is new. I know all this stuff. I've heard it over and over. It's nothing new." You're right! You probably do know all about it and it isn't

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While a member of VA-66 attached to USS INTREPID (CVA-11) and USS ENTERPRISE (CVA(N)-65), he made four Mediterranean deployments. During his first sea duty tour he amassed nearly 400 carrier landings in the A-4 of which over 100 were at night.

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new information. The point is, that all pilot-caused carrier landing accidents have occurred because a pilot broke one or more of these rules for one reason or another. Some pilots continually break these rules, while others are not quite as guilty. The net result is the same—the probability of causing your own accident is increased. To be a professional, you must comply with all of these rules, on every approach!

Every important system in aviation has a backup—electrical system, hydraulic system . . . and when all else fails . . . the escape system is available. When a backup system fails you find people running into each other trying to find out why and rightly so. The backup system should never fail.

The LSO is the backup system in the carrier landing. He must not fail when the pilot fails. The LSO is in the second best position to prevent almost all of the pilot-caused carrier landing accidents. (The pilot obviously is in the best position.) You might argue, "The LSO is powerless if the pilot does something foolish after passing the waveoff point," and you would be *almost* right. If the LSO thoroughly and exhaustively trains his pilots, the pilots in turn will less likely make foolish mistakes after passing the waveoff point.

To: The Landing Signal Officer

Rule 1. Make sure your pilots understand all the proper techniques of landing their particular birds on a carrier. Brief them often. At least once a week, especially while deployed. Don't let combat missions, big exercises or ORIs sidetrack the importance of a proper carrier landing. The pilot's widow will fail to understand how her husband lived through a combat mission only to crash at the ship.

Rule 2. Don't talk to the pilot too much during approaches, because this breeds complacency. Pilots will develop an attitude of "If I'm a little off the LSO will help." This can be a real trouble source in a no-radio situation. Help the pilots if they need it but keep in mind the value of an instructional waveoff.

Rule 3. Don't let "tempo of operations" intimidate you. If you are not 100 percent sure the aircraft can make a safe landing, wave it off. Even if things get so bad the pilot has to eject, it's still better than endangering everyone with a deck crash.

Rule 4. When the aircraft reaches the waveoff point, the pilot should be in a steady state condition for the remainder of the approach. If any large correction is needed at this point he should be waved off. You just can't trust a pilot to react the way he should after he passes this critical point. Let your pilots know they have to please you, *prior* to the waveoff point, not themselves at the deck.

Rule 5. Take the initiative with responsibility. Don't let a RAG student go to the ship for CQ if he is not ready. Tell the commanding officer about a pilot that is having trouble. Give the Air Boss your opinion on wind conditions, weather and deck conditions. *You are the expert—don't keep your information to yourself.*

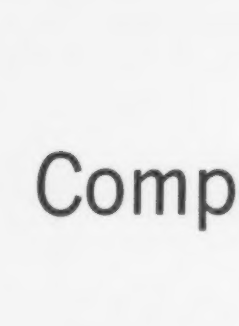
Pilots and LSOs have heard these rules hashed and rehashed many times and yet we still have pilot/LSO-caused accidents. The reason is obvious—either the pilot or the LSO fails to obey all the rules all the time.

The main point for pilots to remember is to make as perfect a start as humanly possible. Concentrate on the entire approach from start to trap; remember the *mission* is not completed until the aircraft is trapped and the chain tie downs are in place.

The sage LSO should continue to speak softly but carry a a big (waveoff) pickle.

3

Approach Power Compensation and YOU!



By CAPT P.T. Llewellyn, USMC
ASO, VMF(AW)-451

Ed. Note: In response to a request by the Naval Aviation Safety Center F-8 Analyst, VMF (AW)-451 has researched and submitted an interesting, thought-provoking treatment on the use of APC during carrier operations.

Information contained herein is based upon VMF-(AW)-451's experience operating APC equipped F-8Ds during a recent eight-month cruise embarked in USS FORRESTAL. *Although involving only F-8 flight operation, 451's treatment of the APC subject can enlighten other carrier pilots yet to utilize APC aboard ship. It is to that group of pilots that this article is directed.*

What Is APC?

Before becoming too involved, a quick presentation of APC's operating principles is in order. APC automatically maintains approach power through changes in angle of attack and normal acceleration, as affected by bank angle, nose altitude changes, turbulence and temperature. The article "APC: Remedy for Airspeed Headaches" (October, 1963 APPROACH) is an excellent presentation in this regard, and has been made required reading for squadron pilots.

VMF(AW)-451 pilots initially became familiar with APC during pre-cruise FMLP. The pilot's first reaction was that APC could not fly an approach as well as using manual throttle. However, this soon proved to be a false conclusion. One of the reasons is that APC allows full visual concentration on line-up and glide slope positioning. Little or no attention need be given to airspeed, power setting, etc. While becoming accustomed to APC, the habit of monitoring throttle movement with the left hand was established. A pilot was thus kept refreshed on power control, but more important, could take immediate action in the event of an APC malfunction. Proficiency was maintained in manual throttle approaches during FMLP by flying the last two passes of each period in manual throttle. A side effect of this procedure was to make APC's advantages more readily apparent.

One of the first lessons to be learned is that a smoother approach must be flown when utilizing APC. There is a slight lag in power response due to APC characteristics and pilot reaction time. This means in effect, the power is "behind" the aircraft. In order to keep it near optimum and the aircraft on glide slope, small and smooth corrections must be made. *Smooth pitch control cannot be overemphasized.* Erratic flying with APC is a quick way to a ramp strike or inflight engagement. APC glide slope changes are comparable to those made with manual

throttle. The same basic power changes are required but are expressed in terms of nose attitude changes. With APC, nose attitude change *is* power change.

Settling at the Ramp

When settling or low in close to the ramp, the technique of manually applying full throttle and disengaging APC was adopted. This method was used in lieu of overrotating the nose and relying on APC to add the necessary amount of power. Nose rotation not only decreases hook to ramp clearance but may have to be rotated so high that increased induced drag becomes critical, requiring even more power. Of course this depends on the magnitude of the correction, as related to the amount of power needed.

Recall if you will that power lags slightly if APC is used. The results are one of the following: If not enough power is added, a ramp strike or hard landing is likely. The other extreme is overrotation with too much power being added. It is a natural reaction to keep pulling the stick aft when settling, often resulting in an extremely nose-high attitude. By the time power catches up with attitude the aircraft crosses the ramp nose high (hook to ramp clearance decreased) with little or no rate or descent. The aircraft will either bolter, or pick up a wire in-flight. Another result is that when attitude is just right, APC responds properly, but in this instance there is very little margin for error—APC application and nose attitude must be exacting. This technique of manually applying throttle can prevent carrier landing accidents and was proven not conducive to boltering. It is utilized only as an in-close technique, or for that point in an approach beyond which it can be used, is a matter of the quality of the approach and individual pilot judgment.

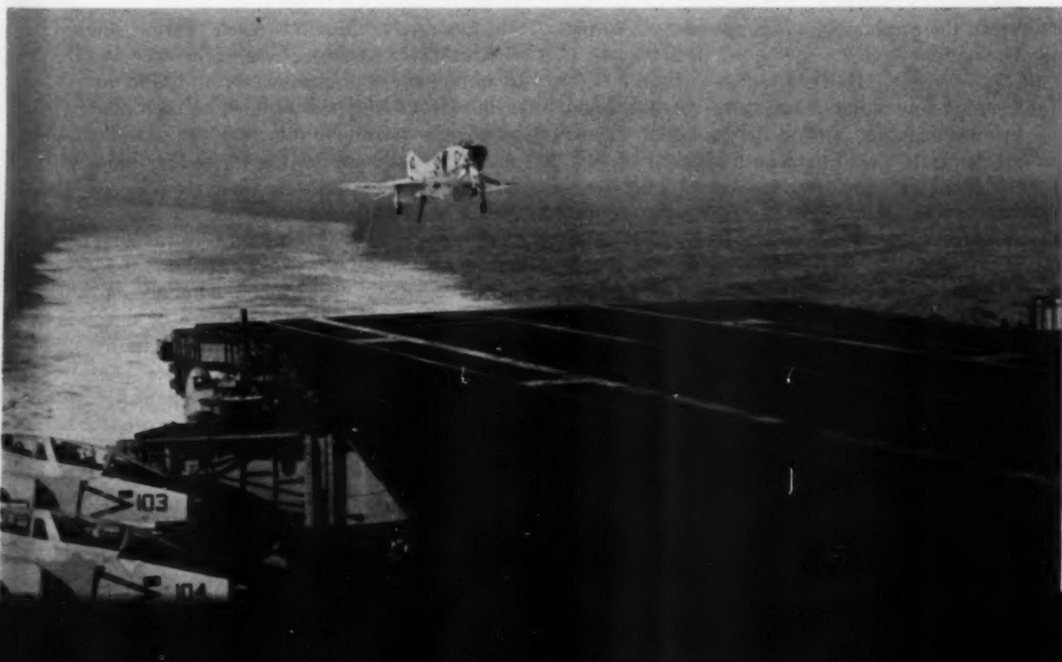
Pilot Demands

Demands placed on APC by pilots depend on how an approach is flown. One who flies a stabilized, on glide slope, okay pass does not demand high power or quick response from APC needed for settling or being low. The pilot who flies such an approach may not gripe a weak or sluggish APC, where the next pilot who gets a low and accepts it, will. Examples of this were observed on several occasions.

Nose-up corrections to counteract a low on straight-in approaches, were found to impair pilot visibility of the lens and carrier deck. A function of angle-of-attack, the F-8's nose tends to obscure pilot line of sight through the center windshield panel when large nose-up corrections are made. This differs from in-close situations or circling approaches. Here the carrier is viewed through the side windshield panel or just to the side of the IR dome and gunsight unit. This visibility problem is most prevalent during the middle portions of a night CCA. Considerable pilot consternation results if trouble is experienced in seeing the meatball or deck lighting during a dark horizonless night. It should be noted that even with a pilot sitting as high as practicable in the F-8 cockpit, this problem still arises if the aircraft goes very low and a large nose-up correction is made. *Another good reason to fly a centered ball.*

APC Maintenance

Problems with maintaining APC manifested themselves due to the lack of a usable APC line tester



CARRIER LANDING DATA

The following is based on a five-month period flying APC equipped F-8s.

		Day & Night	Night Only
1.	Total traps	1254	318
2.	Total bolters	205	69
3.	Total passes	1459	387
4.	Total manual passes	54	10
5.	Total manual pass bolters	5	2
6.	Bolter rates		
	a. Overall	14%	18%
	b. Less hook skips	13%	16%
	c. Manual passes only	9%	17%
7.	Average number of traps per pilot	83.6	21.2
8.	Average number of manual passes per pilot	3.6	.66

Note: Bolter rate = $\frac{\text{Bolters}}{\text{Bolters plus traps}}$

during the latter half of the cruise. As a result of manually calibrating the APC units, performance occasionally varied between individual aircraft. This may account somewhat for APC having been sluggish or weak on occasion. Further, APC performance could not be anticipated before flying the aircraft. Two or three flights were usually required to attain satisfactory adjustment. In order to ensure optimum APC performance without having to guess or fly the aircraft, the availability of an operable APC line tester is a must.

Bolters

Information concerning bolter rates were tabulated for a five-month period during the cruise. It is possible that the rates would have been higher had APC not been involved. However, individual pilot technique must also be considered. For instance, the highest bolter rate during the subject period for individual pilots was 34 percent, while the lowest was 7 percent. These two pilots both had over 90 landings each. It was interesting to note that for all pilots the individual bolter rates were inversely proportional to the number of No. 1 wires picked up. This point applies to carrier flying regardless of APC utilization.

Manual Passes

Regarding manual passes, squadron policy directed the use of APC on every approach where it functioned normally, with one exception. Agreement is taken with the previously mentioned APPROACH article, concerning the degree of safety gained by using APC at all times. The one exception was flying manual throttle approaches when high or gusty surface winds prevailed. This obviated higher than normal nose attitudes, but more important, excessive aircraft nose motion when power changes were required. VMF (AW)-451 pilots averaged six manual throttle carrier landings each during the cruise.

Whether or not there was proficiency in this area is questionable; however, flying APC and monitoring throttle response did help to keep pilots current on power control. No difficulty was experienced with manual throttle approaches where the angle of attack functioned normally. The manual pass bolter rate may not be representative of F8 manual throttle carrier approaches due to the limited number flown.

Lessons Learned

The carrier approach is definitely made easier with APC. We have covered some of the difficulties that may arise with its utilization aboard ship, and how to avoid them. The difficulties only tend to emphasize the reasons for staying on glide slope. *The only way to fly APC is to be smooth, avoid large attitude changes in-close and get set up early in the approach.*

If pilots do this, APC will do the rest.

Keep that Flashlight handy!

While in a port turn on a night flight the pilot and copilot of an S-2D suddenly lost their primary and secondary instrument lighting. This startling turn of events was accompanied by loss of each pilot's gyro horizon, and before the pilot could stabilize with the aid of a flashlight the *Stoof* lost 500 ft.

The electrical failure occurred when the No. 3 Essential Feeder (gang bar breaker on the main distribution panel) popped. Suspected cause of this disconnect was a plastic guard mounted over the No. 3 Essential Feeder, which somehow had become deformed and was vibrating against the end of the gang bar. Experimentation revealed that when pressure was applied against one end of the gang bar, the circuit breaker on the opposite end would pull out. This in turn caused the remaining breakers to pop. Since these guards on nine other squadron aircraft were deformed in a similar manner, procedures were initiated to eliminate this potential hazard.

No one needs to warn an ASW pilot of the possible consequences of an instrument lighting failure during a typical low-level mission at night. However, frequent briefings on how to handle such an emergency will always serve a useful purpose. For example, in the type of electrical failure described above, cockpit flood lights are still available, a point that could be forgotten during a stress-ridden situation unless the pilot was current in his emergency procedures.

Operational Design

Although flight and ground safety have been emphasized more and more during the design, manufacturing and maintenance phases of the aircraft business, the final decisions which directly affect flight safety will rest with the flight crew.

New aircraft such as the General Dynamics F-111 ("*Aerospace Safety,*" December 1965), have received repeated consideration of the various aspects of safety; but the man at the throttle has the last look and the last decision. These determine the fine line between life and death of man and machine. The reasoning behind these decisions should be as sound and objective as the reasoning that goes into the making of the machine.

A "kick the tire, light the fire," attitude will hardly hack the decision cause. Still decisions are often made with such reasoning as, "the airworthiness of the aircraft is directly proportional to the desirability of the mission." This is an axiom that can be developed when the flight crew makes judgment of an aircraft condition in a subjective rather than objective mood. Flight crews are not the only people involved with flying who are exposed to decisions regarding aircraft flight safety, but they are most often the victims of unsound decisions. It then becomes most important that a flight crew decision regarding safety be sound, and as free as possible of those factors which influence subjective thinking.

The chain of safety begins with the initial concept of an aircraft design and continues on through the actual design, the prototype, manufacturing, testing, changes, delivery, operation, inspection, maintenance, overhaul, modification, preflight and flying of the aircraft. Each of these major phases consists of hundreds of lesser operations such as the making of a single rivet or strand of wire. And each of these operations requires other major operations like the manufacture of the machine that makes the rivet. The total idea can be regressed all the way back to the gathering of the basic ore from which the aircraft parts are made. This transition from the depths of the earth to the unlimited heights in space requires thousands of cogs in the giant machinery that produces an aircraft and demands that each cog work nearly perfectly. From each cog, and from each man involved in that cog, the base line of the safety curve is plotted. For each flaw that is created because of subjective thinking, or other reasons, the margin of safety grows smaller and the responsibility of the flight crew broadens.

In many cases, flaws or inherent defects that are created through any of thousands of ways are so small and so insignificant that they will never cause trouble. Other defects, normally dormant, will react when some specific set of circumstances conspires to demand unusual performance. It may be that this is the type of failure which causes an aircraft obituary to end in "cause undetermined."

As the aircraft progresses from design to operational use, many decisions are made. These decisions are made by humans and are subject to the foibles and fallacies of human understanding. A designer leaves off a line of a drawing because he is in a hurry to get to an anniversary dinner. The drawing progresses without the omission being noticed and a part is made. The part fails and through the normal UR system a new, beefed up part is made. An ASC is issued to change all existing parts to the newer part with a new dash number. A clerk is interrupted while typing an order and leaves off the dash number. A condemned part is sent to the field and installed in place of another part that is exactly the same. The inspector checks the work, fails to check for the dash number and the aircraft is cleared to fly—still in the same condition it was in before the part was changed. After a few flights circumstances develop wherein the part is required to perform at its maximum and it is not strong enough. It fails and an aircraft and crew are lost.

One man in a hurry, others complacent, momentary

De sion...  or is it?

As the aircraft progresses from design to operational use, many decisions are made.

distraction of a clerk, an inspector is too routine, and then—monumental disaster!

If such an event can be built into an aircraft, then it behooves the flight crew to practice flight safety to the utmost so that the curve of safety remains well above the base line. Judge harshly those things about the aircraft which you can see, for there are many things about the aircraft which you can't see and are not privileged to judge.

Usually it is not the big killer items that are accepted for flight when they are known to be marginal. Rather, it is the small things that insidiously sneak up and suddenly become as deadly as the bigger items. If a collection were made of last words that preceded infamous flights that ended as "cause undetermined," it might contain such things as:

"It'll hold together until we get to Madrid . . . we'll change it there."

"Who wants to RON in this hole? Let's press on."

"I'll sign it off for a one time flight just to get your requirements completed."

"If the wind holds, we can overfly."

"George said he thinks it's O.K. and he's been flying these birds for years."

"If it doesn't control on takeoff, go to fixed pitch and we ought to make it O.K. like that."

"Rules and regulations are only guide lines."

"I don't have the latest charts, but this one should be O.K."

"If it takes eight hours for that strut to go flat, it should be O.K. for landing when we get there 'cause it's only a six-hour flight."

"It's an external leak and besides that, we have plenty of extra fuel aboard."

"Just take the bulb out, it's probably a circuit malfunction."

These quotations are not necessarily verbatim, but are pretty close. Each time a go, no-go decision is influenced by this type of thinking the curve of safety goes down. Because the sum total of all of the safety of the aircraft comes to a focal point with the flight crew, it is the responsibility of the flight crew to discharge that responsibility in the most professional manner of which they are capable.

Although helmeted heads are in the clouds, the booted feet of flight crews should be firmly planted on the ground when decisions are made. Personal desires should not influence these decisions and an oil leak at Gander should be considered just as serious as if it were at Orly—although the RON possibilities are not nearly as bright.

Mr. Einstein noted that all things are relative and are influenced by the observer. As flight crew, we are particularly susceptible to that relativity and our evaluation of the safety of things can be influenced by circumstances. Those pieces and parts that are unsafe on Tuesday are just as unsafe on Friday, so keep the safety curve solid and constant and stay around to enjoy those softer curves that are not so constant.

—Adapted from "USAF Aerospace Safety"

Approaching Minimums...

TAKE OVER VISUALLY

There are fewer more critical moments in a flight than those approaching minimums under the control of precision radar. If the ceiling is down to 200 ft and your groundspeed is about 140 kts you'll have about 20 sec between breaking out and touching down. Unless you elect to make a missed aproach this will be a pretty busy 20 sec.

First, of course, you'll have to make the decision whether to land or not. Then you'll have to evaluate if you're high or low, fast or slow; you'll have to pick out the runway from the underrun; evaluate the weather, winds and runway condition; separate the runway lights from the maze of approach and city lights; and finally, land the airplane.

Sound like a good workload for a computer? It is. But you've got to do it in less time than it takes Clark Kent to hunt up a phone booth or broom closet. That airplane might not be faster than a speeding bullet, but it's moving toward the runway at 235 ft per sec and that just doesn't give you much time for hemming and hawing or feeding input data to your personal computing section—not if you sit, fat, dumb and happy until your copilot calls runway in sight, passing minimums. The transition from instrument to visual flight has to start quite a bit earlier.

Even a computer can't make a spot decision about anything. It must first be laboriously fed a lot of background data, which it quickly researches for facts on which to base a decision. Your cranium-encased computer likewise has to have stored background data. It got some of this on your first flight in pilot training. More was added each time you flew. Each approach and landing added a little more to your judgment of good and bad landing positions. But some inputs were more subtle. In fact, whether you (or he) knew it, even the PFE who asked you to point out the various aircraft antennas during a walk-around added a bit to your ability to judge an approach. More on that later as we review some of this stored data that may have been erased or

worn a bit thin. We might even put in a little new information.

But knowing how doesn't always get the aircraft on the runway safely. Similarly, buying a utility belt didn't solve all Batman's problems. It merely gave him the tools to do the job. So, we'll also touch on applying your knowledge to the problem on the final approach.

Planning the Destination

Actually, you can start making your landing decision for a particular flight back in the flight planning room. That's a good place for a long, close, first look at the airfield—especially for such things as wind and landing direction, runway layout and airfield lighting. For example, we recently had an aircraft commander land short because he mistook a non-standard row of yellow lights in the approach zone for runway lights. The non-standard configuration was noted with an E*, and the small word "amber" on the approach plate, but red cockpit lighting made these notes hard to read. Also, when the landing lights were turned ON, visibility through the light snowfall was reduced enough to make the red approach and green threshold lights disappear.

The AC had 13,000 hours in the aircraft, and had landed at the base a few times. But he had never landed on that particular runway. He had the plates out as a back-up for the precision approach, but didn't study the lighting diagram.

Before you leave the planning room, cross check the high and low enroute charts and approach plates if you're planning an enroute descent. MEAs and published obstructions may show such descents unadvisable. Also check the field location relative to initial and final approach fixes. Sounds pretty ridiculous, but a few years back a jet ran out of fuel when the pilot found out, after making the letdown, that the approach he had chosen was some 50 miles off base. His reserve fuel hadn't been figured with "down on the deck" consumption rates.

If flying a high altitude aircraft, be sure to have both high and low approach plates and enroute charts out on letdown. Loss of radar or radio contact may require you to revert to the published letdown procedures, so they should be studied and kept handy.

Ceiling and Visibility

You also need to give the approach minimums something more than a cursory glance while flight planning. The minimums for an approach are general-

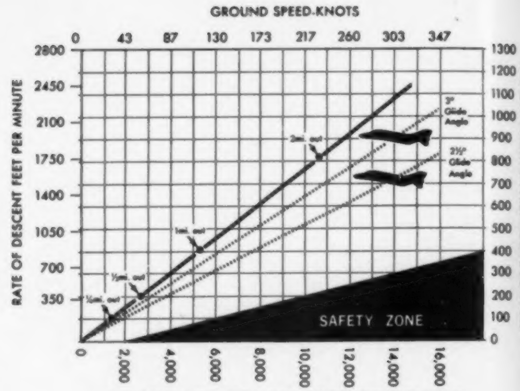


Figure 1. This chart shows glide path angles and rates of descent at various ground speeds for 2½ and 3 degree glide paths. To determine glide path altitude, read up from distance out to glide path line, then right to find height above runway. To find rate of descent, read down from final approach groundspeed to glide path angle, then left to find rate of descent required to remain on glide path. To figure rates of descent from other points, draw a glide path line (as shown in dashed line through 400 & 1 mile point), then compute rate of descent for your groundspeed.

ly dictated by type of approach and obstacle clearance. However, the geometry of these obstacle clearance minimums is seldom compatible with AFR 60-16 weather ceiling and visibility requirements.

For example, on a surveillance (ASR) approach with minimums of 500 and 1, which are more common than you'd expect, you'll reach the minimum altitude about two miles from the runway. But if the visibility is down to minimums, you won't see the runway until you've leveled off at 500 ft and flown for another mile. (This is a 3-degree glide path which is standard for ASRs.) If you do see the runway at visibility minimums, you'll have to set up a descent of over 1250 fpm (at 140 KIAS) to make the normal touchdown point. When ASR minimums are 600 and 1, such as at NAS Moffett or Olmsted AFB, this rate of descent goes up to 1550 fpm. ASR minimums such as the 900 and 1 at Newark Airport become downright impossible, as do the non-precision straight-in minimums of 1000 or 1200 and 1 we see occasionally.

For more specific data, take a look at Figure 1. This is a chart of various distances, altitudes and airspeeds you can use to check rates of descent at the appropriate approach speed for your aircraft. Note that the 1 and 2 mile reference lines are in statute miles, since visibility is also measured in statute miles. Also keep in mind that the table, and the

figures given in the preceding paragraph, don't include delays in recognizing the runway, deciding to land, and establishing the descent. So, the actual rate of descent from a 500 and 1 point will probably be closer to 2000 fpm. This could set you up for a nice sink rate problem and add to your troubles.

The disparity is also found in precision glide paths. On a normal glide path of 2½ to 3 degrees, you'll reach 200 ft about 3.4 mile from the runway/glide path interception point (GPIP). This is ¼ mile before reaching visibility minimums. Unless the GPIP is more than 1000 ft down the runway, or high intensity approach lighting is installed, the copilot probably won't make visual contact if the field is right at minimums. With strobe centerline lights you're all set because in daytime they can be seen through 200 ft of cloud and at 1½ times normal visibility.

But if the approach lighting is a string of red bulbs salvaged from the base Christmas tree, or the GPIP is set near the end of the runway for jet fighter recovery, you could be set up for an embarrassingly short landing. This is especially true if one of the illusions associated with poor visibility makes your glide path look like it's right down the groove and the radar final controller says you are on the glide path without mentioning that the glide path is aimed at the underrun. In one such case, an aircraft landed in a well-lighted motor pool area a few thousand feet short of the runway threshold. Maybe the AC was just tired of waiting for crew busses, but near-white lights can look like runway lights if they're lined up nicely and located where a pilot expects to see a runway. Ask residents of Glyfada, Greece or Ewa Beach, Hawaii, how many times they've been buzzed on rainy nights. Their main streets are just short of, and almost in line with, the respective runways at Athens and Honolulu.

Visual Maneuvering

Is this really how instrument approaches were designed to work? Actually, that question answers itself by virtue of the word "approach." Both precision and non-precision are instrument approaches to visual landings.

Everyone knows they're going to have to do a certain amount of maneuvering after breaking out on a VOR, Tacan or ADF approach, but should a PAR "cut you loose" at 200 ft? Presently the advocates of controller advisories until the aircraft passes over the end of the runway have the upper hand, but there are arguments in opposition to this policy. Maneuvering some models of aircraft to touchdown ends up with a "you're too low for a safe approach" transmission on every landing. Pilots get accustomed to hearing this and might someday disregard valid warnings.

Some aircraft have stopping problems, so we won't go into the pros and cons of "getting into the slot" or whatever you want to call dropping below glide path prior to crossing the threshold. Instead we'll say that SOP is to follow the glide path to the run-

way threshold. Don't mentally shut off the radar controller when you get your first look at the runway. He could save you from a mistake in judgment. If you have any personal ideas along this line, it will be a lot easier to present them to your standardization pilot for an impartial pre-trial evaluation than it will be to convince an investigation board.

Another thought: would you believe any excuses for touching down short of a 10,000 to 14,000-foot strip, whether or not dropping below glide path to set up a touchdown was recommended?

Checking runway length and going "by the book" put two more steps in the landing decision into the preflight phase.

By now you've probably gotten the idea that good flight begins with a good flight plan, so let's move onto the final approach. Specifically, let's go some distance out, just starting down the precision radar final approach. The controller says you're on glide path, on centerline. If you could see through the soup should you get a "RED-WHITE" on the VASI? Not necessarily. The radar controller is centering the blips which may be 50 ft above and below the course/glide path lines. (See Figure 2) The radar glide path allows a tolerance of +0.2 and 0.25 degrees. The landing gear position is something else again. On some aircraft it can be off as much as 30 ft, depending on model aircraft and pitch attitude on approach.

With such variations, can you believe it when the controller says you're 20 ft below glide path? Absolutely! You can bet your "rat hole" fund that the controller on the scope in 200 and $\frac{1}{2}$ weather will have the center of that radar return pinpointed. In better weather, with a student controller, your error might be closer to 40 ft since reading the scope is just as much an art as flying the aircraft right down the glide path. But with training these guys get pretty good. In fact, some even do part of the work for you. We've talked to controllers who ride aircraft like C-124s high on the glide path because they know the aircraft radar return is close to 20 ft above the gear. However, such procedures are contrary to instructions and even a bit dangerous, as we'll see later.

Also bear in mind that a radar return doesn't automatically center at the mid-point of a large object. A good reflecting surface only inches across may show on the scope while 150 ft of wing doesn't. For different model aircraft, the radar return may come

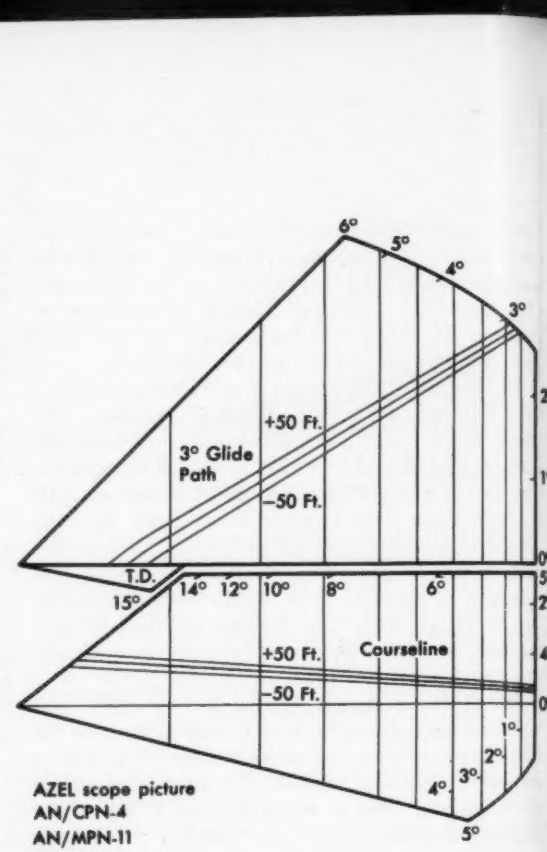


Figure 2. This depiction of a PAR scope shows a 3-degree glide path. Fifty-foot deviation lines are shown only for information. They do not appear on the scope. Vertical lines are mileages from touchdown. Note that the logarithmic scale makes the glide path more accurate close to the threshold.

from different portions of the airframe. This indicates a danger in too much reliance on an exact glide path/aircraft return/landing gear relationship.

While talking about the relative positions of landing gear, let's digress for a moment and take a look at Figure 3. This shows "over the fence" segments of $2\frac{1}{2}°$ and 3° glide paths. On the $2\frac{1}{2}°$ glide path, with the GPIP at the 1000-ft marker, your radar return will be $43\frac{1}{2}$ ft above the threshold as you cross it. This could bring your gear pretty close to touching short in a big bird if you get slightly low. This is particularly true if you go into a base that handles mostly small aircraft and get ridden right down the PAR glide path when, unknowingly, you're accustomed to being brought down a bit high.

We touched briefly on the allowable tolerances on glide paths but 2/10 of a degree is rather meaningless in itself. Let's put it this way; what would

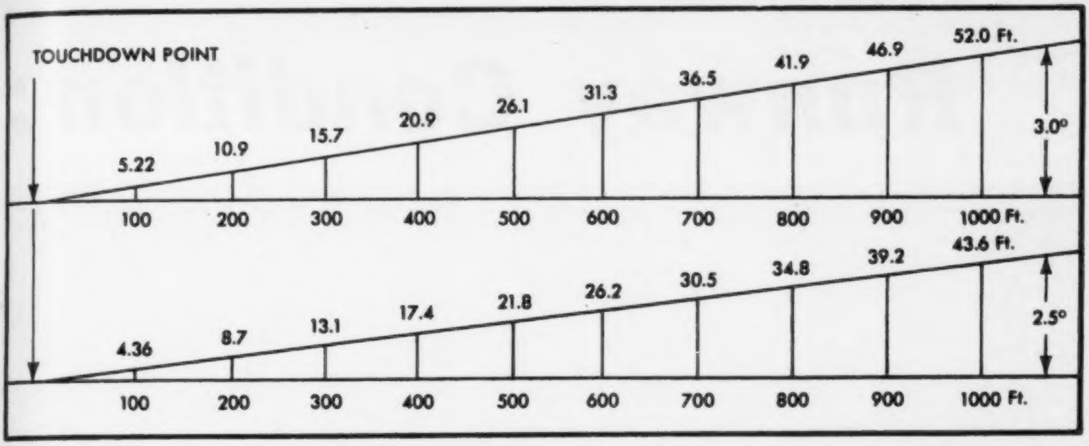


Figure 3. This expanded scale shows height above runway threshold on 2½ and 3-degree glide paths. Note that this is height of radar return, not landing gear clearance.

happen if you were called 200 ft below glide path on a PAR? If there was a check flight you would probably be disqualified on the spot.

Closer in, PAR becomes more sensitive and precise. Looking back at Figure 1, we can see that 50 ft above glide path at ½ mile requires a 400 fpm increase in rate of descent to make the normal touchdown point.

We obtain this figure by noting that at ½ mile, height should be 125 ft and rate of descent at 140 kts is 600 fpm. Mark a point at 175 ft and ½ mile. Draw a line from the origin, through this point, to intersect a line dropped from 140 kts at the top. Then read left to the rate of descent of 1050 ft per minute.

The final approach is the period of greatest crew workload with the least time for decision making. Consequently, the quality of your decision will be adversely affected by this workload and any pressures rising from aircraft emergencies or abnormal conditions. Therefore, the analysis of the approach, and subsequent landing must begin well before reaching minimums; a procedure that's generally called keeping ahead of the aircraft. Literally pre-planning the landing from the ground up will make it a lot easier and safer.

—Adapted from "The MAC Flyer"

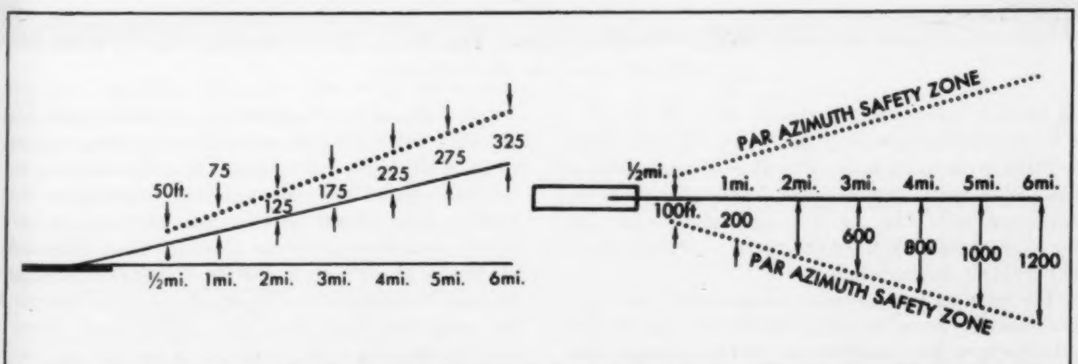


Figure 4. These two diagrams show displacement from PAR glide path and course line. In the left diagram, the PAR elevation safety zone. The right diagram shows the PAR azimuth safety zone.

Runway Condition:

Braking on runways like this can be tricky.

Although pilot-caused accidents have decreased a little statistically over the years, we never seem to make great leaps in the direction of total elimination. With more complex and faster aircraft being developed each day, we are constantly faced with the need of gaining more and more knowledge about our aircraft and aviation.

The learning process never slows down in aviation, but recently more demands have been put on the pilot to keep him qualified in current aircraft. The concept of trying to stay ahead of the aircraft has required us to be more technically knowledgeable than was required in the old days.

Still today a large percentage of pilot-caused accidents occur during the takeoff and landing phases of flight. With this fact in mind, we must therefore be familiar with all the many variables which affect the landing and takeoff performance of our aircraft. Since we are required to acquire more technical knowledge about today's aircraft, we sometimes forget the basic fundamentals of flight affecting our aircraft. *We must, therefore, strive for exacting and professional techniques in the operation of our aircraft during all phases of flight, but most particularly the takeoff and landing phases.*

Friction is created when one body comes into con-

ICE, SNOW, WATER, SLUSH

By LT C.R. Paty, ASO VP-49

tact with another. When the wheels of an aircraft roll down the runway on takeoff and landing, a certain amount of friction is created. This friction, when expressed as the relation between friction force and normal force, is known as the coefficient of friction, expressed as the Greek letter U (mu). Thus, the coefficient of friction formula is derived:

$$\frac{\text{Friction Force}}{\text{Normal Force}} = \frac{FF}{N} = \mu$$

The coefficient of friction of tires on a runway, is a function of many factors; i.e., runway surface condition, runway surface composition, rubber composition of the tire, tire tread, tire inflation pressure, speed at which brakes are applied, amount of brake application, ... A pilot does not have control over all of these factors. However, braking on a runway can be an advantage to the pilot *only* if it is done properly.

When brakes are applied, torque is transmitted to the wheel which retards rotation. This first application of brakes produces a braking torque, but the first retarding torque is balanced by the increase in friction which produces a rolling type of torque. The retarding torque produced by brake application causes an increase in friction between the tire and the runway surface. A constant rotational speed is experienced when the braking and rolling torques are equal.

The most common error in brake application is too much application. This develops a braking torque much greater than the greatest possible rolling torque, causing the wheel to decelerate in rotation to the point where it becomes locked. With the wheel locked the tire begins to skid or slip on the runway surface, causing the coefficient of friction to decrease. The type of runway surface or surface condition will determine the rapidity of this decrease and the peak reached by the coefficient of friction prior to the slip.

The most effective braking occurs at the peak coefficient of friction and this peak is reached just prior to the beginning of tire slip. Figure 1 shows the effect of slip velocity on the coefficient of friction. The figures used are not exact, but are used to illustrate the relationship of different runway conditions.

As noted before, the coefficient of friction depends on many factors. This peak can best be illustrated by locking the brakes on your car at a certain speed and measuring the distance required to stop. At the

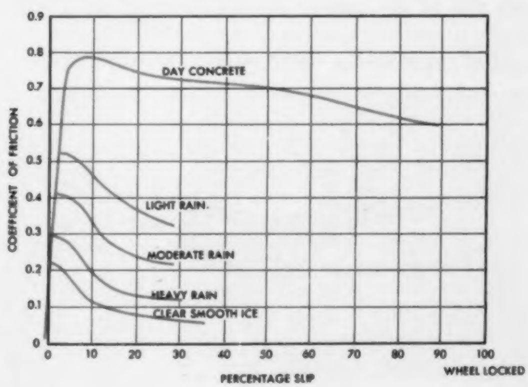


Figure 1

same speed, apply the brakes to the point of skidding, releasing them slightly if skidding starts and then compare the distances. The distance with the brakes locked will always be greater.

The coefficient of friction is greatly affected by ice, snow, slush, and water on the runway. For example, snow covered runways are twice as slippery as dry concrete runways. Ice covered runways can be from 4 to 16 times as slippery as dry concrete runways. This wide range depends on the temperature of the ice. Ice near the melting point is the most slippery. The element of speed on dry snow or ice covered runways has little effect on the coefficient of friction. Conversely, the element of speed has a great effect on the coefficient of friction on runways covered with slush or water. As speed increases the coefficient of friction decreases sometimes to a point equal to that of ice beginning to melt slightly. When the speed approaches this point on slush or water covered runways, the result is hydroplaning.

Hydroplaning requires a fluid depth of at least 0.1 to 0.4 inches. This is determined by the smoothness of the tires and the pavement. The smoother the tires or the pavement, the less the fluid depth required for hydroplaning. Hydroplaning is a direct result of fluid depth, speed, and tire inflation pressure; therefore the formula, $Vp = 9\ p$ can be used to determine the approximate hydroplaning speed, if the conditions are right. Vp is the hydoplaning speed in kts. p is the tire inflation pressure in psi. For example under ideal hydroplaning conditions, an aircraft tire with a pressure of 144 psi would hydroplane at 108 kts.

Under the right conditions, hydroplaning can occur during landing or takeoff. The most serious problem associated with hydroplaning is the effects of a crosswind. In a situation like this the aircraft will side slip off the runway toward the resultant downwind, if corrective action is not taken.

Slush or standing water on the runway increases

Not many aircraft are equipped with skis. Pilots must be familiar with the performance of their particular aircraft.

the takeoff distance as a result of the increased drag of the tires displacing the fluid in its path. During landing on slush covered runways, stopping distances can double or even triple the distances required for dry runways and sometimes cause complete loss of directional control when crosswinds are encountered. Reverse thrust, if available, should be used to slow the aircraft below the hydroplaning speed so the tires can take hold and help some directional control. However, reverse thrust should be used with caution as it can increase the drift toward the downwind side of the runway. The use of asymmetrical power, when available, can be used to maintain directional control.

During takeoffs, treat everything as slush except

Slush Depth	Dry Snow Depth	Approximate Increase in Lift-Off Distance
1/4 inch	3 inches	6%
1/2 inch	4 inches	15%
3/4 inch	5 inches	28%
1 inch		50%

Figure 2

dry snow. Figure 2 shows the increased distance to lift-off caused by various depths of slush and dry snow. As speed increases on takeoff, there will be a definite nose-down pitch caused by drag on the wheels. Increased stick force will be required to break the nosewheel free of the slush.

On icy runways touchdown speed should be the slowest possible to decrease rollout. Braking should be used only intermittently to prevent skidding. Extreme caution should be used when landing downwind or crosswind on icy runways.

The purpose of this article has been to inform the reader of anticipated performance of aircraft during takeoff and landing under different runway conditions. It is not meant to advise the experienced pilot in control of his particular aircraft, but is meant to create thinking on the part of the pilot during the critical phase of flight.

In marginal conditions the pilot should know and anticipate the reactions required to control his aircraft. In multipiloted aircraft those procedures and anticipated reactions should be discussed verbally with the copilot and understood prior to landing. The decision still rests with the pilot whether to land or proceed to his alternate.

Each naval aviator has before him a world of knowledge to be gained and he should take advantage of every publication available to increase his knowledge about his particular aircraft. Only then can we make great leaps in the direction of decreasing pilot caused accidents.

Use of Full Pressure Suit in In-Flight Emergency

EDITOR'S NOTE: *The following account of the use of the full pressure suit under emergency conditions due to loss of cabin pressure at and above 45,000 feet was forwarded to the Safety Center by Commander, Naval Air Systems Command for dissemination. The original report came from CDR Leroy B. Cochran, MSC, Physiological Training Unit MCAS, Cherry Point.*

Report Subject: Loss of cabin pressurization in an F-4B aircraft during a training flight with the pilot and radar intercept officer wearing the Mk-4 full pressure suit.

Background information: In the interest of flight safety, most people involved in the full pressure suit program feel that no high altitude flight should ever be made without the use of the full pressure suit. Unfortunately, there are some who wish to take the calculated risk of not having a malfunction in the cabin pressurization system. Inflight operations, utilizing the full pressure suit, data or case histories have been limited whereby it could be pointed out that personnel and/or aircraft have been protected. This episode, which occurred at this Marine Air Station, serves as an example of the protection provided by the full pressure suit.

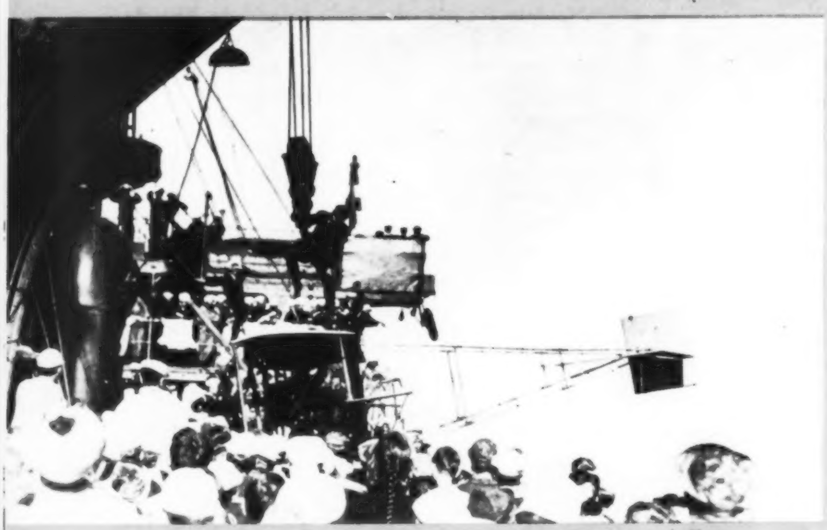
Details of the inflight incident (as told to this writer): On 3 June 1966 preparations were made for a full pressure suit high altitude training flight. After a thorough aircraft check-out the pilot made a normal takeoff and ascended to FL 390. During the climb out, the programming of cabin pressurization functioned properly. At FL 390 the pilot dumped cabin pressurization in order to make an in-flight check of the full pressure suit and its related equipment. The suits became slightly pressurized and the pilot and RIO were satisfied and prepared to make a zoom climb. After turning the pressurization switch ON, the pilot nosed over slightly and attained a speed of 1.6 Mach indicated at FL 350 (cabin altitude prior to high altitude run is not known). At this point, approximately a 30-degree climb was initiated. As the aircraft was passing through FL 480 to FL 500 the pressure suits became pressurized and the pilot observed the cabin altitude increasing. An abort manuever was initiated. However, the aircraft attained a maximum altitude between FL 570 and FL 580 ambient, and the cabin altitude at this time was noted to be FL 530. Both the pilot's and RIO's full pressure suits functioned perfectly. The aircraft descended to a safe altitude and the flight was terminated. Needless to say, these two men were very pleased and complimentary about the full pressure suit.

Discussion: An attempt was made to determine the *cause* of the loss of cabin pressurization. The yellow sheets were reviewed for remarks made by the pilot and discrepancies corrected. It appears that the most likely cause was either a malfunction of the bellows which activates a proper canopy seal or perhaps a malfunction of the cabin pressurization regulator. In this aircraft, the pressurization regulator is not protected from the possibility of some debris entering, thus prohibiting a proper closure or seal. The yellow sheet did show that an adjustment was made on the bellows and subsequent flights of the aircraft did not show any discrepancies in the pressurization system. The aircraft is now going through PAR and these systems will be thoroughly checked.

A permanent record is being maintained at the Naval Aviation Safety Center of incidents involving full pressure suits in flight. Inputs are requested. Send to Naval Aviation Safety Center, U. S. Naval Air Station, Norfolk, Virginia 23511.

DECK EDGE COAMING REPORT

Now . . .



. . . and Then.

"How do you keep them down on the (bird) farm?

CAUSES for over-the-side aircraft losses and for dropping a wheel into the catwalk as depicted here are numerous. Inadvertent towbar disconnects, slippery decks, ship heel during turns, brake failure, lack of brake riders, misplaced chocks, insufficient tie-downs to name a few.

To reduce the possibility of such mishaps Ship Alt CVA 2832/CVS-500 provides for installation of raised deck-edge coamings along the port and starboard flight deck outboard edges. Locations vary with ship design. The ship alt specifices coamings to be six inches high and capable of stopping a rolling aircraft.

To date, only USS ENTERPRISE (CVA-N-65) has the ship alt incorporated.

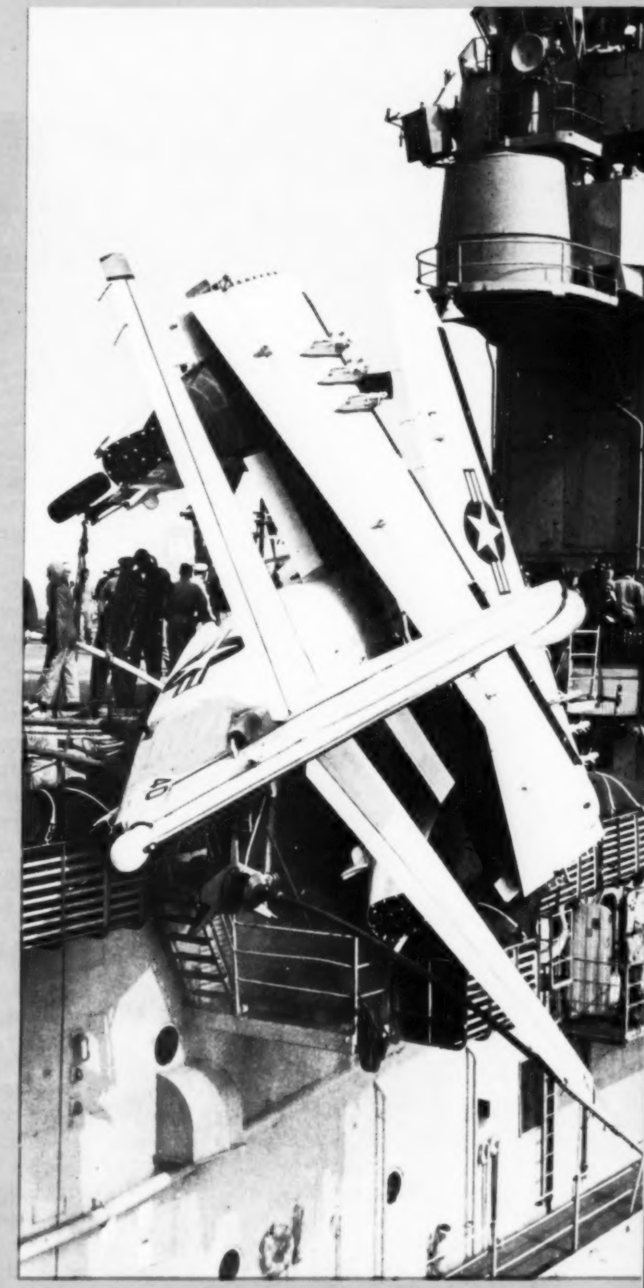
The ship reports ". . . that the configuration was simple in design, inexpensive to install (about $10 per foot), and has been easy to maintain. Despite initial apprehension from some flight deck personnel, no interference with flight deck evolutions has been experienced.

"Notwithstanding lack of aircraft saves, other factors of obviously increased aircraft safety, non-interference with flight deck evolutions, low cost, simple installation and easy upkeep make this coaming a highly desirable design feature. It is strongly recommended that a flight deck edge coaming similar to that installed in ENTERPRISE be provided for all carriers."

Like the Air Boss says, "I like NSLI and USGLI, even if I haven't collected."

Some drop into catwalks . . .

. . . some are lost over the side . . .
. . . very few are recovered . . .



Deck-edge coaming, starboard and port can make a safer deck tomorrow.

Short Snorts

Styrofoam Will Burn

At a recent aviation safety council meeting, one of the participants gave a very vivid demonstration of what can happen when a pressed styrofoam cup, of the type sometimes included in aircraft box lunches, is used for an ashtray.

He broke off a small piece of one of these cups and placed a match to it. The styrofoam readily ignited and burned in a very sooty manner. It was easily seen that a cigarette could produce the same results. The council recommended that styrofoam cups not be used aboard any aircraft based at their station.

—NAS Argentia Safety Council Notes

Cleanliness of Runways And Taxiways

The P-3A Safety Officer reported that rocks on runways and taxiways are a potential source of damage to propeller aircraft during reversing operations. The rocks are deposited by wind, vehicles, aircraft and to some extent are found in the sand used to improve runway braking action. The Public Works representative stated that action was being taken to improve the quality of sand, and that a regular inspection and sweeping program *is in effect*. However, the presence of rocks is a continuing problem at Keflavik. It was suggested that the squadron review operating procedures to reduce the use of propeller reversing below 50 kts and in the taxi mode. The council recommended a review of standard operating procedures to ensure frequent inspection of runways regardless of weather conditions. The presence of rocks on runways, taxiways and ramps is an item requiring continuous vigilance on the part of all aircraft and equipment operators and management personnel.—*ASO VP-10*

"Terming to Worming"

Use of words in communicating "What happened" is a common problem in accident reporting—be it military or civilian. Some thoughts offering grist for the good of the order appeared recently in a letter to the editor of the *Army Aviation Digest*, quoted herewith.

"A review of aircraft accident reports at Seventh Army Headquarters has revealed that some accident boards are confusing the use of the term 'knowledge' with the terms 'proficiency' and 'judgment.' An evaluation is in order to determine what is meant when a board's findings state that the accident was caused by an apparent lack of knowledge, proficiency, or judgment. A review of the meaning of each word is required so that each term can be placed in its proper perspective in an accident investigation.

"Knowledge is acquired through study. It is an acquaintance with, or perception of, facts or truths. Thus, in applying this to our situation, a lack of knowledge stems from a lack of familiarity of flying information which is known or may be known.

"Proficiency, however, is synonymous with the words 'skilled' or 'expert.' A lack of proficiency is indicative of a lack of skill, or lack of expertness in flying abilities, when applied to the aviator.

"Judgment on the other hand is a mental conclusion made from evaluation of information available to the pilot. When poor judgment is used, it is caused by either a lack of information (knowledge) or by improper use of the information which was available to the pilot. One can say then that proficiency is acquired through knowledge, but only after the attainment of a certain level of skill.

"Assume that we have equipped ourselves with the required knowledge and proficiency, and an unfavorable situation or emergency develops in the cockpit. Now the pilot makes a snap decision (judgment) based on immediately available mental information (knowledge). He puts his skill (proficiency) to work and comes out smelling like a hero. If any of these parts are missing, or the makeup of any one of the three is incomplete, we are faced with the inevitable accident.

"Moral: Become knowledgeable to increase your proficiency to the extent that when faced with unfavorable situations your judgment will be automatic and correct. This is less painful than a red faced confrontation with your buddies and your superiors after an accident."

Instrument Displays

A study of the psychological aspects of instrument display spelled out 270 cases of gross errors during instrument flying. These errors, in a descending order of frequency, were due to:

- Misinterpretation of multi-revolution instruments
- Reversal of bank/pitch/heading indications
- Misinterpretation of signals or indications
- Confusion between similar instruments
- Forgetting
- Misinterpretation of illegible or poorly displayed scales

For example . . .

On a circling approach in low ceiling/low visibility conditions, the pilot glanced out of the window to look for the runway. Looking back at the altimeter, he misinterpreted the top bank indices as showing a right bank although he was in a steep left turn, and he rolled the aircraft to an almost vertical bank before realizing his error.

While cruising IFR another pilot suddenly noticed his airspeed (drum and pointer-type instrument) reading 90 kts. He abruptly pushed forward on the control column, causing structural damage to the aircraft and injury to several crewmembers. The actual airspeed had been 190 kts.

In both of the above cases and in several others not reported here, the one prevailing factor was increased workload on the pilot; either a hazardous weather situation, an aircraft emergency or some form of preoccupation or distraction.

—Flight Safety Foundation Accident Prevention Bulletin

Vision Transition

The increase in stage lengths of air carrier flight has introduced a new problem to pilots, namely, rough landings. Conversely at the end of short-haul trips pilots almost always make very good landing. Why?

The problem seems to lie in the eye's indisposition to accurate distance and depth perception after relatively long periods of flying at high altitudes. There being nothing outside the cockpit for the pilot's eyes to focus on, his focal distance becomes established at a mere three and a half feet. Therefore, at the end of the trip, when the pilot comes in for his landing, this induced muscular lethargy of the eyes produces inaccurate distance and depth perception. The result: a landing you can't brag about.

On short-stage flights where altitudes are relatively low and frequent landings are made, the pilot's eyes are constantly exercised by focusing on objects first inside then outside the cockpit. The result: good landings, smooth as a . . . well, really smooth and gentle.

Pilots flying the high and fairly long trips recommend the following as a solution to the problem:

On your letdown to the airport and beginning at an altitude of about 1000 ft give your eyes some tune-up by looking back and forth from the instruments inside the cockpit to the horizon as well as to objects on the ground. Then by the time you come in over the threshold, your eyes will have "limbered up" to give you instant and accurate depth and distance perception. The result: continued good landings.

Try it, if you've made some rough landings lately.

Reprinted from an old APPROACH

NEW IGNITING METHOD FOR M

The old familiar Mk 13 Day and Night Distress Signa ow o

many

Rece

i

developed a AD C

Screening, and Mar

signal label to reflect new

are literally thousands of these signals the sy

out completely the igniting method as printed on the Mk label.

many cases and leaves you holding a signal that's not a signal because it cannot be led. S

bend it down over the rim of the signal body and then flip it back to its original position w the

shown to be almost 100 percent reliable. Step-by-step procedures for using the Mk 13 Signa e as

(Incidentally, the night flame end is identified by raised humps or projections around the mfere

cap or cover from the end to be used. 3 Grasp the pull ring and flip it over the rim of th ignal

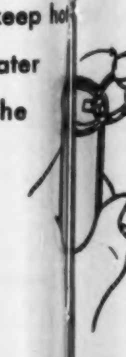
2) until the seal snaps, which it sometimes doesn't do. If the seal refuses to snap with this d of

body as shown in Sketch 3. 5 Flip the bent ring back to the top of the signal and press do (Sket

from your face and body and give a sharp yank on the pull ring. This will ignite the smoke flame

mately 45 degrees from the horizontal with your arm fully extended. The angle will keep hot

drippings from burning your hand. 8 After using one end, dunk the signal in the water to cool it and save the other end just in case you might need it later. So that's it. The good old Mk 13 will do a good job for you if you don't twist its tail.



Prepared by: R.T. Frothingham, Research and Development Dept., and M. Gilpatrick, Quality Evaluation Laboratory Dept., NAD Crane, Indiana

MK 13-0 DISTRESS SIGNALS

ow officially Marine Smoke and Illumination Signal, Mk 13 Mod O) has been a trusted standby many years as a Here-I-Am, Please-Come-and-Get-Me device for survivors on water and land. Recently, however, numerous complaints have been heard that, all too frequently, the igniting method as outlined on the signal body label doesn't work. Either the pull ring twists off entirely or the soldered seal simply refuses to separate. The end result, alarming if not slightly catastrophic to the would-be user, is that he doesn't get action. The signals themselves are very effective once they are ignited. The difficulty seems to lie in trying to ignite them in accordance with the printed rules. A new igniting method has recently been AD Crane and has been incorporated in the First Revision of NAVWEPS OP 2213, Pyrotechnic, Marking Devices, as Change 1. In addition, appropriate steps have been taken to change the new method when new procurement of the Mk 13 becomes necessary. In the meantime, there he system, and not too many of you will get a chance to see OP 2213. This new method rules label. Tests have proved that the old recommended twisting force tears the pull ring off in too led. So don't twist the pull ring with your thumb and forefinger as it says on the can. Instead, the bend can be used as a lever to break the seal. Sounds simple, doesn't it? It has been e as follows: 1 Choose the end suitable for the signal needed: smoke for day, flame for night. mference of the case, approximately 1/4 inch from that end.) 2 Remove the paper (or plastic) ignal case as shown in Sketch 1. 4 Press down the overhanging ring with your thumb (Sketch d of force, continue pressing on the ring so that it bends over the rim and against the signal (Sketch 4), using the bent pull ring as a lever. 6 After the seal breaks, point the signal away flame composition, whichever you choose to use. 7 Hold the signal at an angle of approxi-

1 2 3 4

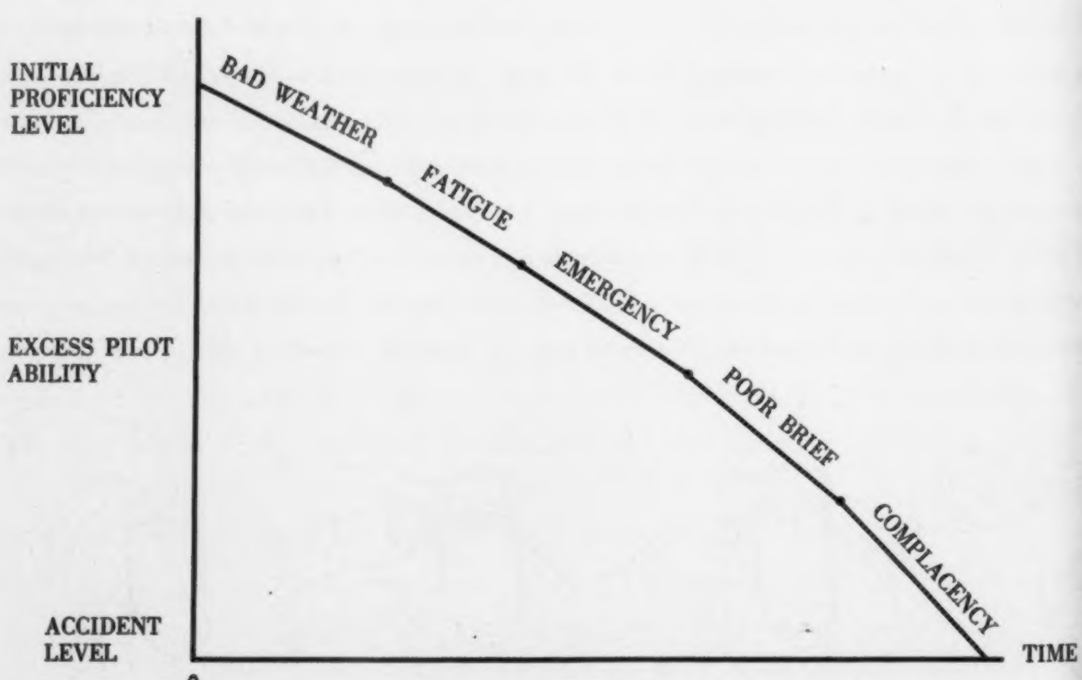
Details,

By LCDR D. S. Teachout, ASO, VS-37

It's the little things that count! By little things I don't mean trivial matters. I am referring to the small—but important—details that play a vital role in the successful completion of an evolution. This statement, although valid in all fields, is particularly pertinent with respect to naval aviation because the margin of error in this area is minute. The purpose of the following discussion is to emphasize the importance of these seemingly minor details.

Aircraft accidents are seldom, if ever, caused by single catastrophic incidents. The usual sequence is for a series of minor problems and/or mechanical failures to occur. Eventually the point will be reached at which the ability of the individual pilot or the capability of the aircraft is exceeded. An accident is the inevitable result when this point is passed.

Below is a graphic representation of this point.



it's the little things that count!

It is a pictorial presentation of the final flight of LT Joe Gish—a typical young tiger. At time 0, LT Gish reports ready, willing and able to tackle any assigned mission. However, as time passes various factors, which are familiar to us all, come into play. Each of these factors tends to reduce pilot proficiency.

The first of these factors which Joe encountered was a deteriorating weather problem. Since Joe was an all-weather pilot, bad weather shouldn't be any problem at all. Nevertheless, unusually severe or unexpected weather can occur. A *careful* check of the weather before *each* flight reduces the possibility of weather becoming a factor should an accident occur. A flight into heavy weather is not normally a problem whereas, the same flight plus radio difficulties (or other emergency) could have hair all over it. Joe decided to discount the possibility of compounding problems.

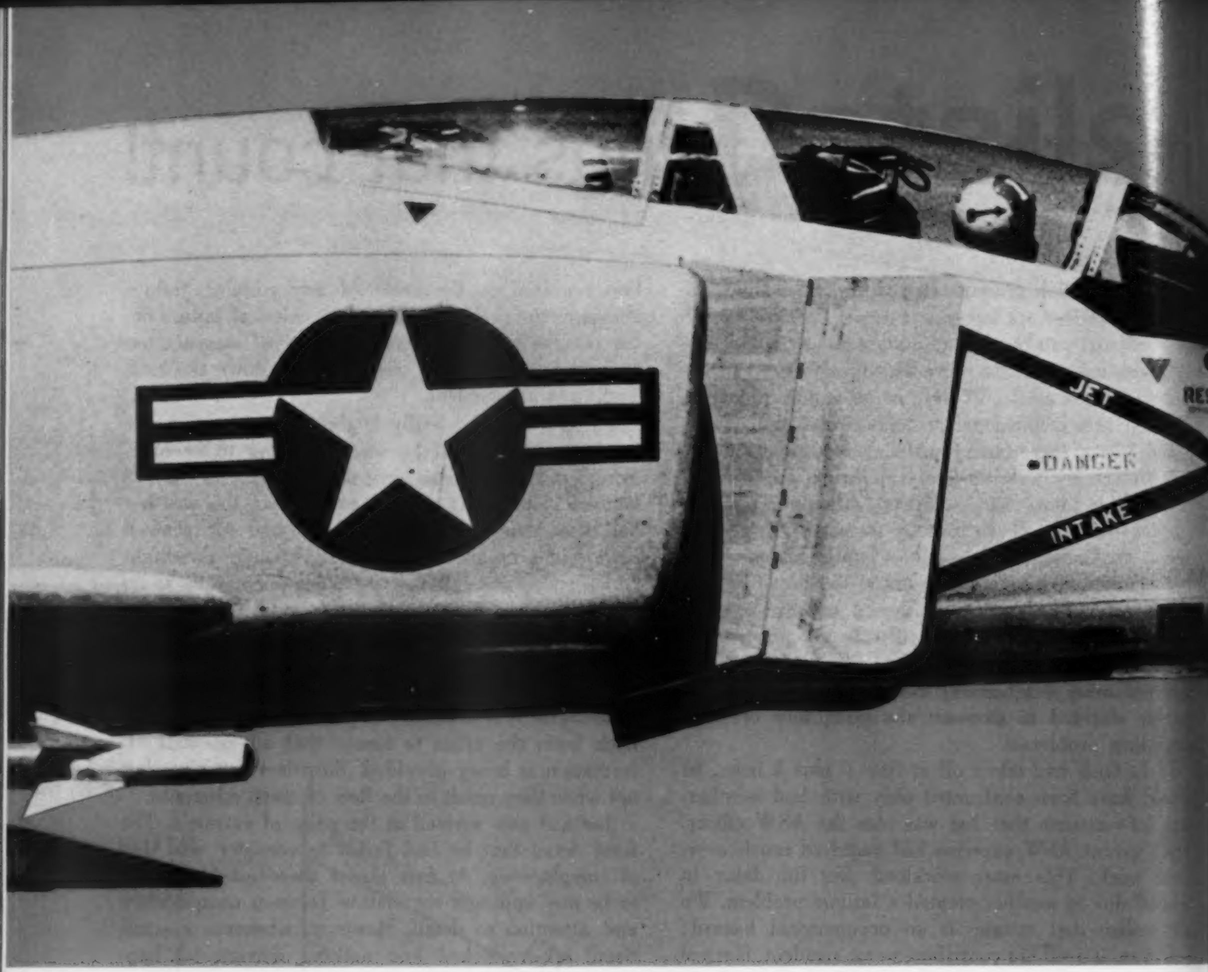
If Lt Gish had taken off at time 0 plus 1 hour, he would have been confronted only with bad weather. But let's assume that Joe was also the ASW officer. The current ASW exercise had required much overtime work. This extra workload plus the delay in takeoff due to weather created a fatigue problem. We all realize that fatigue is an occupational hazard; however, it need not contribute to an accident. Normal squadron work can be programmed with the flight schedule in mind. Occasionally, in spite of careful planning, an individual pilot will pick up a bonafide case of fatigue. When this point is reached, the pilot, operations officer, and/or flight surgeon should insure that the pilot is not scheduled. In Joe's case, this action was not taken. Result—a bit more of Joe's "excess pilot ability" was erased.

Sometime during this final flight Joe encountered an emergency. It could have been a single engine, lost comm, or an electrical fire. The actual emergency was not as important as was the fact that something requiring corrective action took place. True, mechanical failures can happen any time. However, thorough preflight inspections, aggressive quality control programs, proper pilot weekly inspections, and complete, accurate yellow sheet write-ups greatly reduce the number of such failures. Furthermore a frequent review of emergency procedures and corrective action required in the event of any possible failure alleviates the problem should a mechanical failure occur. In Joe's case, the emergency itself was not too serious, but it was just one more step down the road leading to an accident.

By now Joe was really beginning to perspire. He began to realize that he was beginning to be overextended. His problems were not over, however. Since he had leaped into the air as soon as the weather had lifted to an acceptable level, Joe had not received a thorough up-to-date briefing. Although the flight had been briefed initially, the tactical situation, radio frequencies, or flight procedures could be quite different from those of the original brief. A *thorough* current brief prior to each flight should be mandatory. In addition to this, if these briefings are to be meaningful it is necessary to periodically obtain feedback from the pilots to insure that all essential information is being provided. Surprises are nice, but not when they result in the flow of much adrenalin.

Joe had now arrived at the point of extremis. The final detail that he had failed to consider was that of complacency. At first glance there may not seem to be any apparent correlation between complacency and attention to detail. However, whenever a small detail is overlooked and nothing detrimental happens, complacency becomes a more serious problem. Eventually this complacency can in turn induce a pilot to be inattentive to even significant details. In this example Joe's complacency had encouraged him to casually check the weather, overlook the factor of fatigue, and fail to receive an accurate flight brief. The result was a million dollar crunch.

Each of the individual problem areas discussed in this example weren't in themselves critical. Joe could have easily handled any one of them. It was the aggregate effect of all of the minor problems that created the one big problem. Even though it's not likely that all of these incidents would happen on any single flight, it is a possibility. The only acceptable corrective action is to prevent small problems from snowballing into big crises. In naval aviation there is only one acceptable standard—outstanding. The dividing line between outstanding and mediocre is attention to detail.

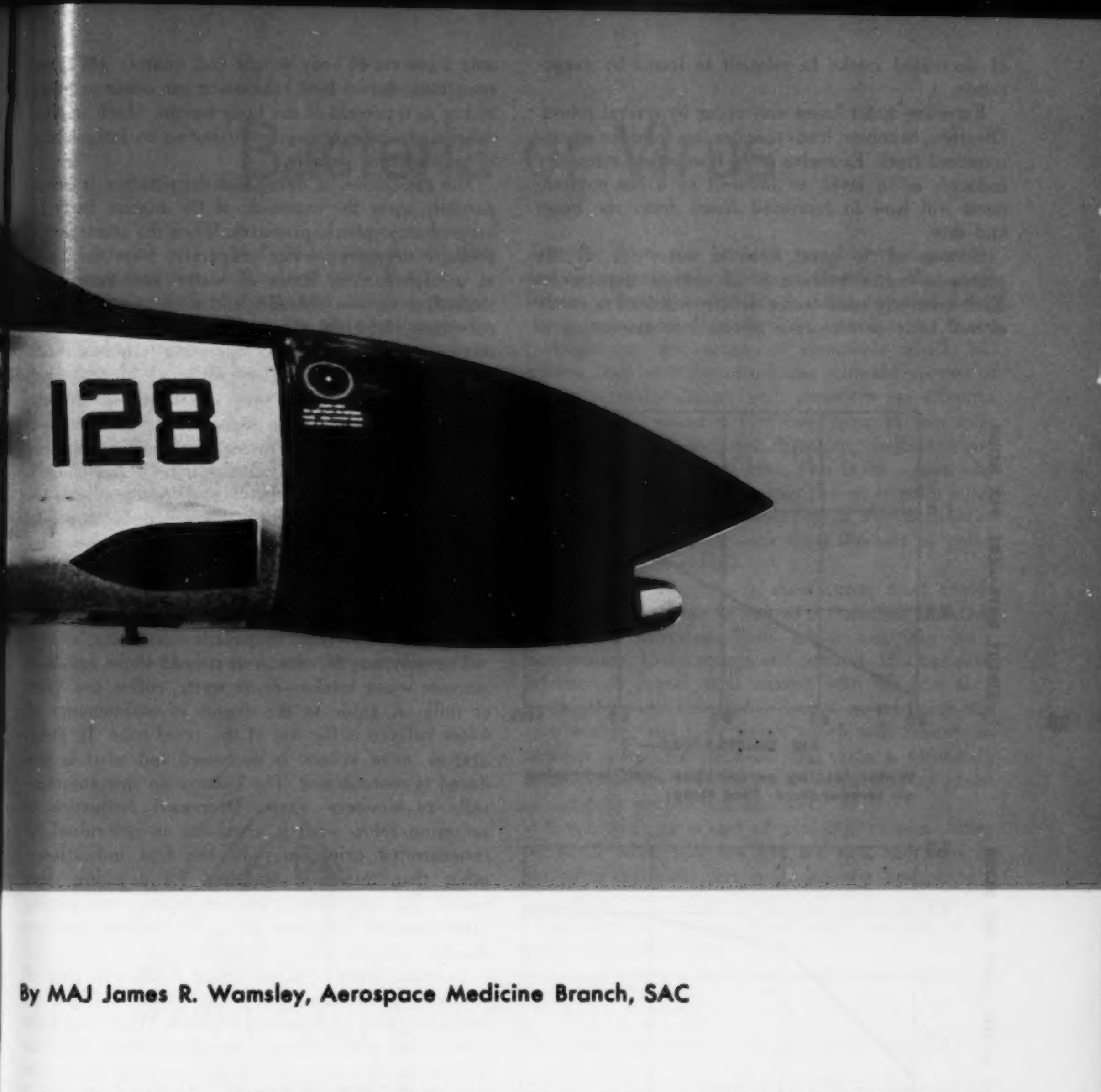


DRY FLY

Flying is a thirsty business. Hypoxia, disorientation, decompression and other physiological effects of altitude all receive their due in our training endeavors. One problem, however, has received little attention—that of dehydration.

Dehydration occurs with excessive loss of body water and you have no doubt heard it discussed in relation to desert survival. Survival, though, is not the only situation in which dehydration can be a complication. Significant dehydration can and does occur in flying, especially with high cabin altitudes. It can also have serious effects in aggravating fatigue and in reducing effectiveness. Perhaps a short review of the physiology of body water balance would help in explaining this.

The human body is over 60 percent water by weight. Land animals evolved from water-dwelling creatures, and in that evolution retained the water environment but enclosed it within the skin. Of the total body water only about 7 percent is utilized as circulating fluid (blood plasma), with 33 percent bathing the body cells and 60 percent contained with-



By MAJ James R. Wamsley, Aerospace Medicine Branch, SAC

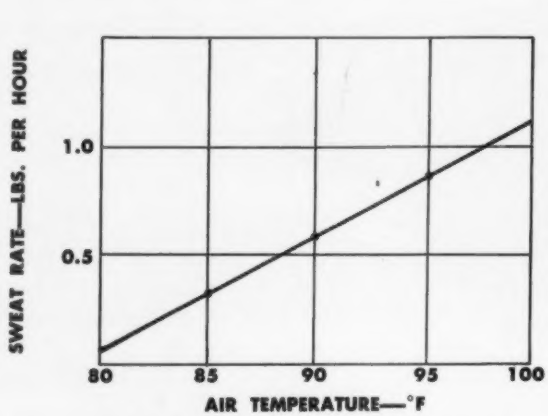
in the cells. We are dependent upon this fluid for all physiological functions; food and oxygen are dissolved and carried to the cells, waste products are carried away, and the very chemical reactions of life itself occur in water solution. This body of water is not static. There is a constant flow from the cells into the blood and back, as well as exchange of water with the environment. The body takes advantage of normal losses of water to the outside world for elimination of wastes by way of the kidney and for cooling by evaporation from the skin and lungs. These normal losses are balanced by drinking water. It is only when the losses are greater than the intake that dehydration occurs.

Under normal circumstances, the average adult human will lose about 2400 cc's of water per day, or 100 cc's per hour. The normal conditions are rarely met however, and the intake requirement to meet these losses must be considered a minimum and valid only in "no sweat" circumstances. In any case, the kidneys can handle increased water intake but must work harder to conserve water in the face

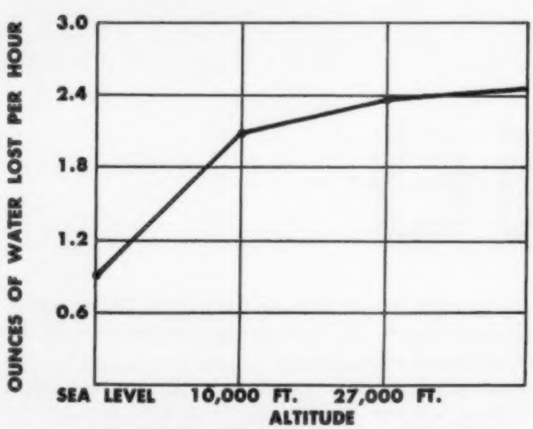
of decreased intake in relation to losses by evaporation.

Excessive water losses may occur by several routes. Diarrhea, of course, leads to water loss from the gastrointestinal tract. Excessive body heat either internally induced, as in fever, or induced by a hot environment will lead to increased losses from the lungs and skin.

Because of the great need of water for all life processes, water balance is of critical importance. Even relatively small water deficits will lead to subtly altered body performance. Water loss amounting to



Water loss by perspiration with increasing air temperature (See Note)



Increase in water loss by evaporation (sweat free) with increasing altitude. (See Note)

NOTE: These figures were adapted from the *NASA Bioastronautics Data Book* (NASA SP-3006) and are furnished for illustration only. One pound of water approximates one pint of water.

only 2 percent of body weight (1-2 quarts) will cause symptoms. Actual heat exhaustion can occur at losses as low as 6 percent of the body weight. Much smaller deficits are important in contributing to fatigue and to performance deficits.

The association of flying and dehydration is based partially upon the exposure of the human body to lowered atmospheric pressures. When the atmospheric pressure decreases, water evaporates from the body at a higher rate. Rates of water loss have been studied at various altitudes and even at usual cabin pressures (5-10,000 ft) evaporation is significantly increased. Under normal operating circumstances, this loss is small but under conditions of prolonged flight the loss becomes very significant in the absence of adequate water replacement. This loss, of course, will be greatly increased if cabin temperatures are high or if the atmosphere is particularly dry—as it is at altitude. These combinations are sometimes related to grossly abnormal flight conditions but a crew can be exposed to all of these factors in more usual circumstances. One has only to think of an hour spent on a hot runway in preparation for 8-10 hours at altitude to realize that all the conditions will be met to increase evaporation markedly.

The only way to counter increased water loss is to increase water intake—drink water, coffee, tea, juice or milk. A guide to the degree of maintenance of water balance is the use of the relief tube. In dehydration, urine volume is decreased and what is produced is concentrated. The kidneys do this automatically to conserve water. Decreased frequency of urination below what is usual for an individual, or concentrated urine, may be the first indication—other than thirst—of the need for drinking more water. The best approach is prevention, and gulping large amounts of water or juices remains the best answer and the best prevention.

Constant water intake during flight will pay off in more ways than in just preventing in-flight dehydration with its fatiguing features. Flyers who have been faced with survival situations report that the first thing they have noted upon hitting the ground was thirst. In most cases this has been the result of drying out during flight. Adequate water provision in survival kits has always been a problem, but shortage will be a much less immediate problem to the flyer who is well hydrated at the time he hits the silk.

Our advice, then, is to drink while flying—water, that is. You may be high and dry on the outside but you'll stay wet and functional on the inside where it counts.

Adapted from "Combat Crew," June, 1966

Bacteria or Virus

Ever wonder why your flight surgeon doesn't give you a shot of penicillin for a cold? Read on . . .

Germs may be divided into two different groups, bacteria and viruses. They are all microscopically small, living organisms present almost everywhere in the world in great number. Viruses are much smaller than bacteria which makes the use of strong electron microscopes necessary to see most of them. Bacteria cause such diseases as pneumonia, boils, strep throat and kidney infection; viruses cause such diseases as hepatitis, measles, mumps, infectious mononucleosis and common colds.

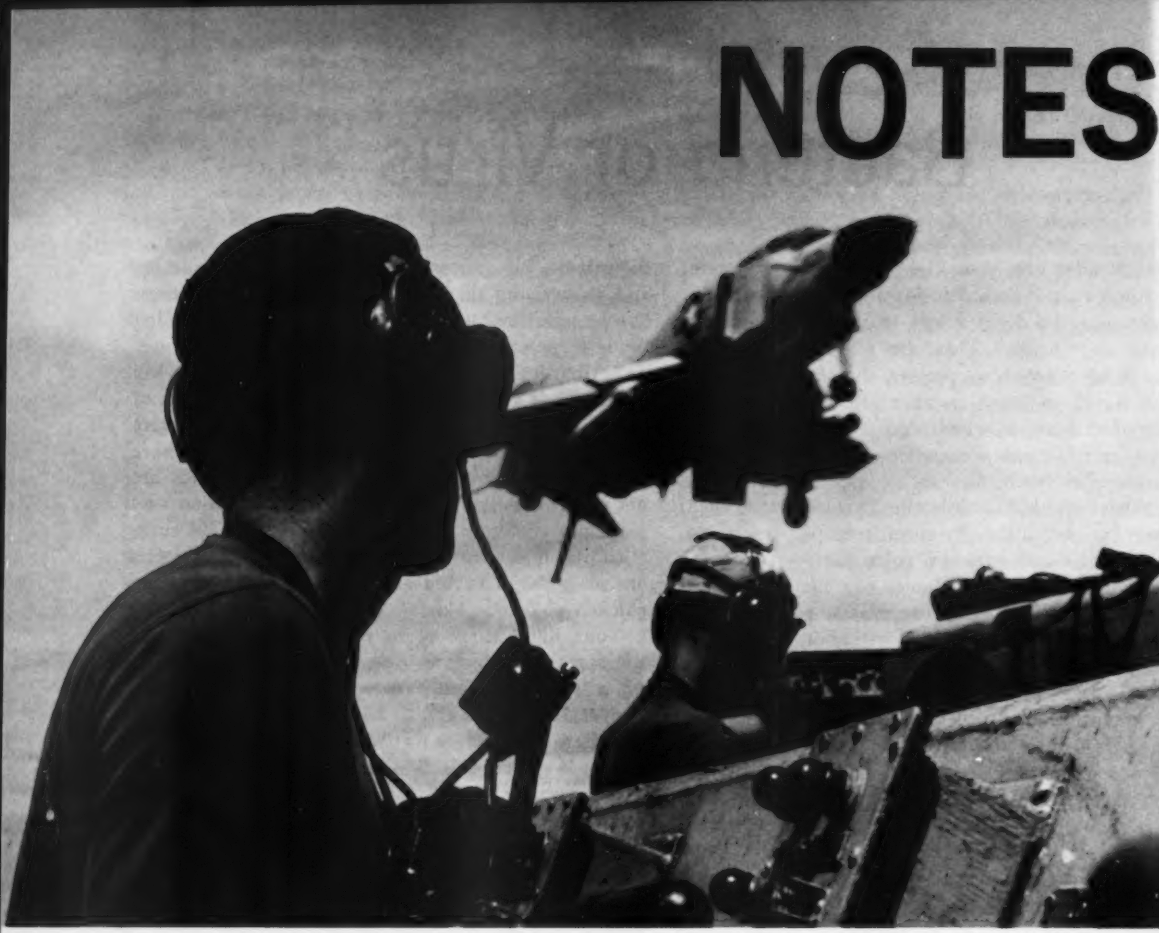
Bacteria and viruses differ in one major respect: Bacteria are self-sufficient organisms, each capable of taking in food, digesting it, using it for energy, excreting waste products and self reproduction. They have all the "internal machinery" necessary for digestion of food. Viruses lack the machinery for digesting food and are only capable of instructing and supervising this function; therefore, they must live as parasites, instructing bacteria or other living tissue to perform their digestive functions for them.

Antibiotics are drugs or chemicals which kill germs. They work by interfering with the process of digestion (metabolism) and, therefore are effective in destroying bacteria. However, since viruses have no internal machinery for digestion, antibiotics are not useful in destroying them. This is the reason why penicillin rapidly cures a strep throat or sulfa cures a kidney infection. Likewise, this is why antibiotics are no good in curing such viral illnesses as polio, chicken pox and colds.

Your flight surgeon, in most cases, must decide whether your illness is due to a bacterial infection or a viral infection. Tests which help are body temperature, blood counts and cultures. If a bacterial infection is found, it is treated with the best antibiotic. If a viral infection is found, no medicine will give a cure, and only drugs which will relieve infectious symptoms are used. The virus is ultimately destroyed by the body's natural defenses, being greatly aided by proper rest and diet.

If you don't get a shot of penicillin or some other antibiotic when you feel you are sick and need it, don't feel that your care is inadequate. You probably have a viral illness, and your flight surgeon is wisely choosing not be expose you to the risk of an antibiotic unnecessarily.

NOTES



Preservation of Hearing

PERSONNEL regularly exposed to the various noises associated with the maintenance and operation of modern aircraft will *all* have their hearing *permanently damaged* unless some effort is made to protect it. There are essentially *no* exceptions to this statement, and bearing out this fact is the continuous stream of annual re-enlistment and aircrew physical exams among aviation personnel which all show this loss. How can we prevent this damage to one of our most vital sense organs? How can we preserve what hearing we have left? How can we restore what we have lost?

The story of sound begins with physics. A source of noise creates sound waves just as a stone tossed into a pond creates waves which move outward in all directions. Just as waves of water have force when striking a solid object, such as a sea-wall, so do sound waves have force when they strike an area such as the eardrum. Larger waves impart more energy and very large waves cause damage.

The loudness or intensity of noise is measured in decibels, and it is an expression of how big or forceful the sound waves are—or how much energy the waves impart when striking a resistance. Low intensity noises are soft and pleasant. High intensity noises are uncomfortable, even painful

from your Flight Surgeon

at times.

We have learned, by bitter experience, that high intensity noises bombarding the delicate hearing mechanism in the ear cause damage and a loss of hearing. At first, the loss is temporary, such as that experienced by a person who has a gun or explosion go off nearby. In hours, or at most a few days, the ringing and partial deafness goes away and hearing returns to normal. If the loud noise is constant or repeated, however, the loss of hearing becomes permanent and can never be restored. By the time such a person realizes his hearing is bad, it is too late to do anything about it.

The simple truth is that the *only way* to prevent such damage is to protect the hearing with some device which reduces the intensity of the noise actually reaching the inner ear.

The Navy has instituted a program of hearing conservation to protect the hearing of all hands exposed to potentially damaging noises. The program consists of periodic audiograms to check the hearing, and the use of appropriate protective devices such as ear plugs, "Mickey Mouse" ears or both.

It is necessary that each man who is exposed to this hazard be aware of the danger and take the necessary steps to protect himself. The responsibility, for all practical purposes, rests upon the individual because of the difficulty of enforcing compliance with formal instruction. All activities have determined their needs for protection and they encourage each man's cooperation. The rest is up to you, the individual, so do your part. The Navy's only interest is *your* set of ears, and remember, by the time you discover you are partially deaf, there is nothing Medical can do to restore this vital function.

—VAW-12, "The Bat"

Legs Float

WHILE awaiting rescue after ejecting over water from an RA-5C, a pilot could not keep his feet beneath him because of residual air in the legs of his anti-G suit. Maneuverability in this position, he reported, was nil. He was unable to grasp his pararaft kit which was dangling uninflated just beneath his reach so he released it. Each wave that lifted him up spun him about so that he could not keep the rescue helo in sight and he made little headway swimming.

Pick up was finally effected by lowering the rescue seat so that the wire could be dragged across to him. He grabbed the cable and followed it to the seat.

You can dump the air in the anti-G suit by depressing the valve on the end of the hose. Another way to cope with this situation is to pull the anti-G suit zipper up until it breaks away and releases the suit from your legs.

Worth Quoting

"THE RIO involved in this rescue made a statement worth quoting in full:

" 'This has been the second year in a row that this squadron has practiced helo pickups while in the Mediterranean. I feel this training helped immeasurably in making this rescue the routine operation that it was. Everything from start to finish was just as practiced. . .' "

—Flight surgeon in MOR

Qualification Mandatory

POST-accident examination of records of the crew of an S-2E lost with all aboard showed that one of the crewmen was not qualified in survival swimming or the Dilbert Dunker. He had failed survival training four months before and at that time had been judged by the physiology training instructor as a poor swimmer.

The crewman's test was rescheduled for the following month but he did not retake it because of TAD orders. The month of the accident, the squadron survival officer gave him verbal permission to practice his swimming and retake the test in the next few weeks. The survival officer was not aware that the man would be flying as an aircrewman on the upcoming deployment. No record was ever found that he had ever passed the survival swim and Dilbert Dunker although it seemed to the investigators improbable that he was not at one time qualified.

"A non-swimmer faced with a ditching situation has very little chance of survival," the Aircraft Accident Investigation Board stated. "The squadron must insure that each crew member is qualified and current in all phases of survival training."

(For requirements for aircrewman swimming qualification, see June, 1966 APPROACH*, p. 23.—Ed.)*

FAILURE ANALYSIS OF AIRCRAFT PARTS

Fig. 1—Electron microscope evidence of fatigue failure aluminum alloy—magnification 6000X. (Note telltale "beach marks" like ripples of windblown sand that indicate fatigue cycles)

By William A. Sipes

Aeronautical Materials Laboratory

Naval Air Engineering Center

Most of the widely publicized scientific breakthroughs have been successful responses to repeated failures. For these reasons, failure analysis at the Aeronautical Materials Laboratory has become a carefully nurtured capability. At AML, the results of such investigations lead not only to short-range fixes for a variety of O&R or fleet difficulties, but they also result in the long-range benefit of giving designers better insight as to operational realities.

Failure Analysis stands in a pivotal position between the actualities of the field and the theories of the drawing board. Those that are engaged in this work must become adept at scientific problem-solving. To say it in another way, the engineer assigned to such work must be an efficient detective. He must do more than see small details, he must observe them in all their interrelationships as facts. He must have, to quote Sherlock Holmes, a "curious analytical reasoning from effects to causes," known as the power of deduction. In addition to this, a wide range of exact knowledge in materials science and technology as well as persistence is required.

To continue the foregoing analogy of the detective,

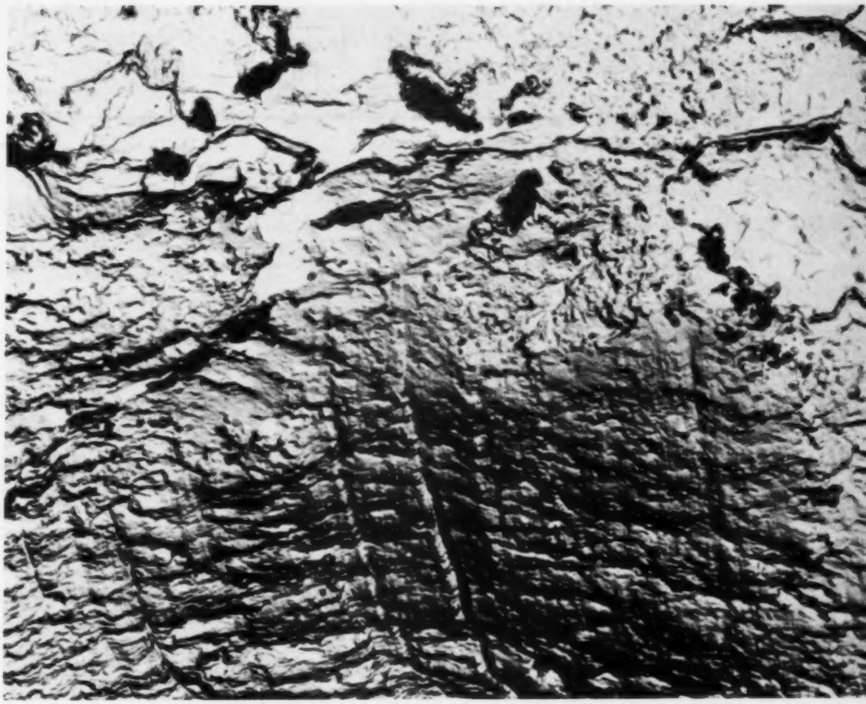


Fig. 2—Electron microscope evidence of corrosion steel—Magnification 6000X. (The "rock candy" look, or the baked out mud in a dried-out creek bottom, indicate corrosion effects)

a broken part, very often hardly identifiable, can be construed as the corpus delicti. For this reason, everything connected with the failure must come to the attention of the materials engineer, since he, unlike a detective, very rarely has the opportunity of visiting the scene of the crime. Nor does he, for that matter have the chance to question eyewitnesses. Nevertheless, through his training, which in the final analysis develops only as an art, the materials engineer can obtain the necessary information by a disciplined application of the scientific and technical procedures at his command. Very often, this produces results that appear almost magical to those outside the profession.

The actual procedures followed in any particular Failure Analysis are as different and varied as the individual problems they may present. An investigation of the failed part, however, usually begins by giving a very careful scrutiny to the available fractured surfaces. The use of the word "available" is well advised. When one considers what an oily fingerprint can do to a freshly polished metal surface, it is a miracle that the nascent, or new-born surfaces of fractures survive long enough to give the information that they do. The greatest help that anyone in the field can give the materials engineers, is to insist that the handling of broken parts must not further compromise the fracture surfaces beyond the damage they have already received in the failure. That is, if the body must be moved, let it be accomplished carefully.

The importance of protecting the fracture faces can hardly be overemphasized. It is by reading these surfaces that the metallurgist can practice one of his most ancient arts. An experienced eye with the help of a simple hand magnifier can readily detect in certain materials whether or not the fracture was brittle or ductile. Quite often the initiating point for the failure can be determined. Further, one can sometimes tell whether or not the part failed by fatigue or because of corrosion. Sometimes the optical microscope is found useful, but with increasing frequency, the electron microscope, because of its depth of focus, is preferred to arbitrate more difficult cases. Figures 1 and 2 show electron photomicrographs which indicate failure modes that were hidden from the more

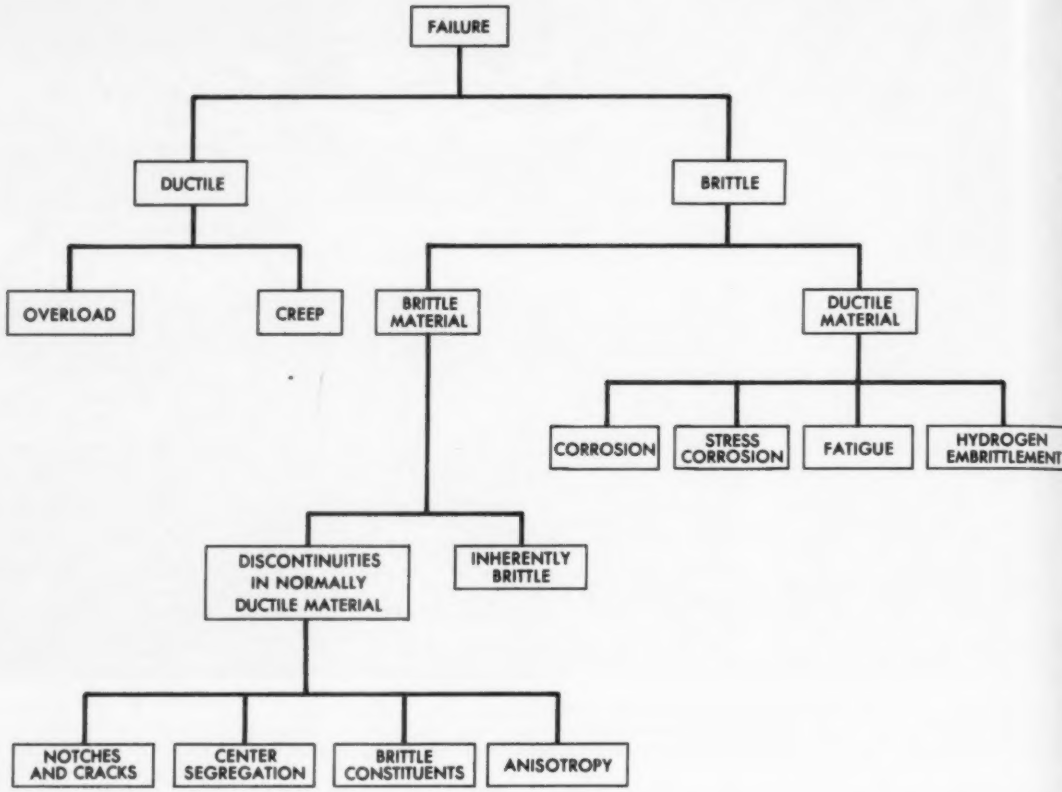


Fig. 3—A classification chart of failure mechanisms from "Metal Failures in Naval Aircraft" by R. H. Gassner, Navy/Douglas Symposium, Long Beach Calif., 10 July 1963.

gross views of the hand magnifier and the optical microscope. But, as has been pointed out and the chart shown in Fig. 3 indicates, the discovery and assignment of a failure mode, although just the first step, can be a most difficult task.

It is by making studies of this sort that the engineer obtains a hypothesis as to how the part may have failed. He then must prove his assumptions and demonstrate that his conclusions properly follow from the premises. If the proper blueprints and other information on, say, the repair of the aircraft (manuals, inspection reports, etc.) are available, the task of visualizing the operation of the part can be made easier. Frequently, even if such information exists, it cannot be obtained readily. Then the materials engineer must fall back on his knowledge of aircraft and missile structure and operation. His experience with the requirements of processing variables and fabrication schedules, detailed study of test methods, and in fact anything else in his background that can provide a clue often may provide the leverage required to "break the case."

As the investigation requires, consultations are held with specialists of all sorts. Their advice and conclusions are submitted to the same careful checking and cross-referencing that is done with all leads. Sometimes a gas turbine expert or a structural design engineer is questioned. On other occasions, it might be a chemist, corrosion specialist, or spectroscopist who is most helpful. Failure analysis requires the special skills of cross-examination and diplomacy. It most certainly requires that its results are not the product of a vested interest in one sort of conclusions. The expertise that is most necessary might be defined as the expert use of information that is obtained from the experts.

On the basis of the crucial decisions made during the initial phases of the investigation, further tests

are programmed to develop supporting data. As reference to the chart classifying failure mechanisms, Fig. 3, indicates, the different types of failure suggest different approaches that such studies would require. Chemical spot tests might interfere with replication of specimens to be used for electron microscope studies. Metallographic specimens which are improperly chosen might not only give false information but their removal may interfere with the possibility of removing specimens for mechanical testing. A casual approach to this problem could well result in destroying the possibility of obtaining the necessary data required to establish the cause of failure. Yet, at the same time, a test very well can result in opening up an entirely new field for investigation. Thus, the materials might be likened to the pathologist, who by his very discriminating test, provides the doctor with the means of arriving at a proper diagnosis. For the materials scientist, as for the doctor, no one test, nor even a series of tests, can be considered sufficient in itself without an evaluating judgment as regards the total situation.

So far, the objectives, the abilities, and general method of attack of the materials engineer have been discussed in regard to the problems presented by Failure Analysis. Perhaps more interesting and as examples of the dollars and cents that are involved in this activity of the AML are the following case histories presented as brief illustrations. For instance, one base reported continual failures of an elevator tab push rod on the C-117. After a number of similar failures in a six-month period, one was sent to AML since the annoyance had now become a mystery. Investigation did not permit one to blame the failure on stress corrosion—that old standby among the causes for failure. It was determined that the failure actually was not a material deterioration. (It is a rule-of-thumb in the trade that 90 percent of failures are not caused by materials at all.) The trouble lay in the fact that the rivets holding the part together had been improperly fastened, so that the joint efficiency was reduced by up to 33 percent.

Numerous reports and investigations have been made of such matters. Or, one might take the case of improperly torqued spark plugs, just for another example. One wonders how many thousands of dollars have been spent on answering $5 questions to solve mysteries which are not mysteries, least of all "material failures." It is a tremendous letdown to discover at the end of several weeks' work that it has only been proved that an improper torque wrench has been used.

On the other hand, not all the problems which come to the attention of the AML are so neatly solved —nor are they so trivial. One of the faster operational planes of the Navy had developed a distressing habit of structurally dropping its nose. It was not a catastrophic sort of trouble but disturbing for a number of reasons, among them the fact that it took 600-700 man-hours to repair. And the repair, having once been made, could not be guaranteed to provide a fix. A quick and easy solution had been suggested but that cut down on the operational efficiency of the plane. A great deal of time and money had been spent to discover the cause of failure. It was not that it was hard to discover where the failure occurred, but the difficulty was in determining just why it happened. It should be remembered that a recommendation of the wrong solution is just as devastating and expensive as the original failure. Hence, since laboratory and structural mockups failed to pinpoint the trouble, repairs were delayed.

Fortunately, the failures involved very few planes. But as long as it could not be proved that it was fatigue or bad design, the laboratory could make no clear-cut recommendation. Finally, some operational service broken parts were sent directly from the field to the AML. This was fortuitous, because when the fracture faces were examined it was quickly noticed that the cracks showed drippings of zinc chromate paint primer. That could have happened only if the fracture had occurred before the part had been assembled. First, then, it had to be proved that it was the primer. Spot tests and X-ray fluorescence analysis were able to check this. Next, it had to be found out just how and where the damage had occurred that resulted in the failure. Here the contractor's reports and previous work were of great help. Also, the process and fabrication schedules for the individual failed parts were scanned. At such times as this all the detailed work of identifying each part, having a record of its history, inspection schedule, and all the other little bothersome items pays off.

From these, it was discovered that the failures occurred in only certain planes which had parts made by a particular subcontractor. Finally, checking the processing schedule, and noting the place where residual stresses could appear in the part (their intensity and character had been confirmed by experimental stress analysis), an estimate of the place in the fabricating procedure where the damage could have occurred was made. But more important than placing the blame or establishing who was responsible was the fact that the aircraft could be made operationally sound. And this could be done without fear that it would be compromised continually by

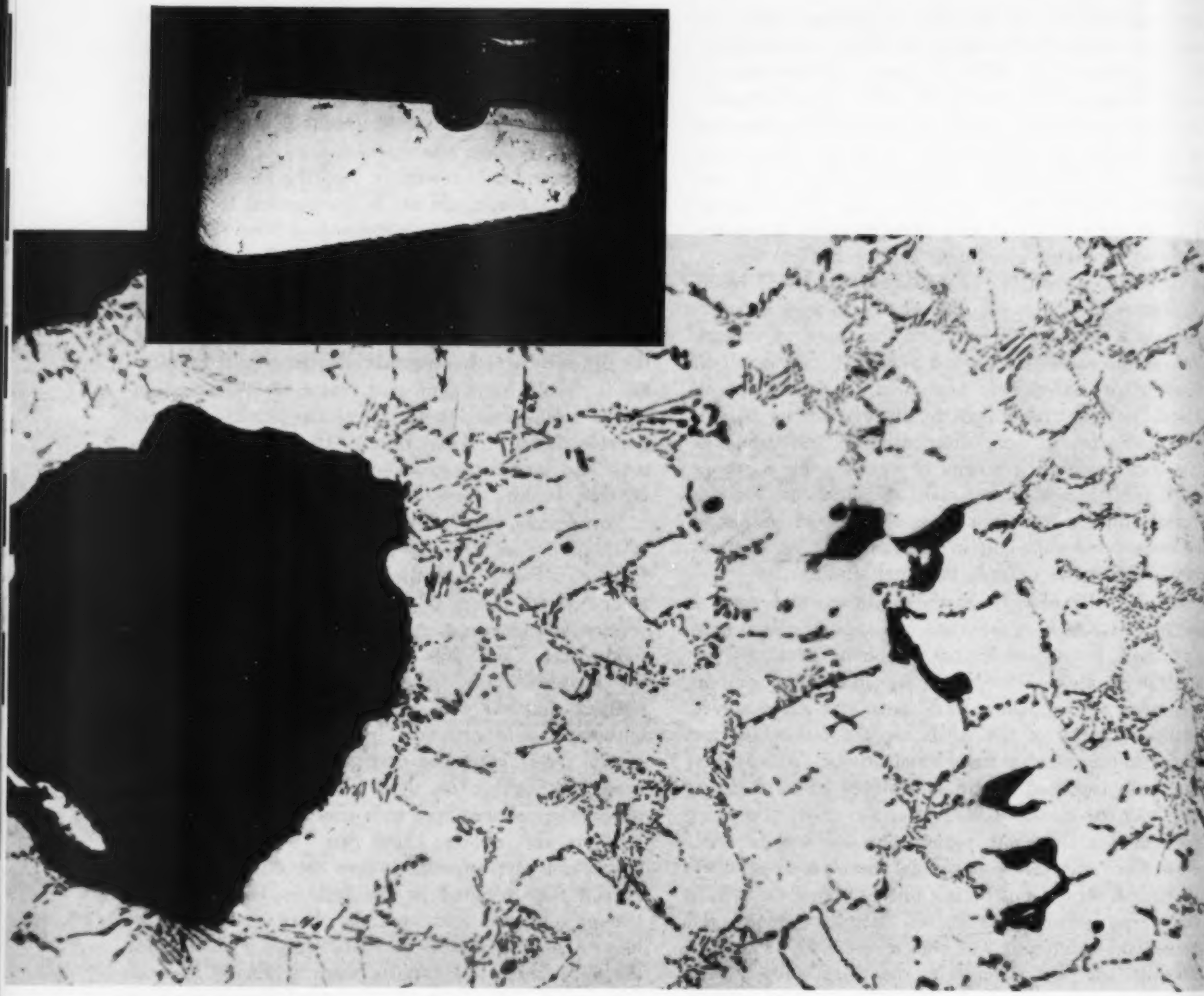


Fig 4—Photomicrograph showing microshrinkage in grease-fitting area of the same helicopter control casting (Magnification 100X).

the mysterious fault. Thus, a problem of some bafflement was solved.

Failure Analysis also means that not only are money or valuable equipment salvaged, but the lives of men who use the equipment are spared. A defective refueling nozzle may mean the death of a pilot who attempts a midair connection with the tanker, as well as the loss of the plane. Cracked landing gear cylinders, broken bomb hooks, or poor quality castings can be lethal. If the three men of a sister service flying a routine stateside patrol who lost their lives because of micro-shrinkage in the cast helicopter-control-rod parts, could speak, they would argue "quality all the way" (See Fig. 4). It is for reasons like these that the materials engineer insists on the facts—as many as he can get.

Briefly sketched, it can be seen that the Failure Analysis undertaken by the AML shows results in lives saved, money effectively used, and research properly oriented toward making the Navy second to none. Often the job is tedious and deemed unimportant by some, but one never knows just which piece of lint will actually lead to the unraveling of a difficulty. Failure Analysis is the only way to achieve the required result.

Using the Torque Wrench

The operation of a torque wrench is not complicated. However, to properly use a torque wrench, the mechanic must possess a basic knowledge of torquing mechanics, and as with any precision measuring tool, must exercise a reasonable amount of care and skill.

Force Application—When using a torque wrench, the force must be applied with a smooth steady pull up to the desired torque to obtain accurate torque values. Rapid or jerky pull up can result in considerable error in the torque applied.

Reading Torque—With the indicating dial-type wrench, the torque is read on the dial as the force is applied. With the audible or click-type wrench, the torque is present on the wrench by releasing the lock in the end of the handle and rotating the grip to the desired torque setting. When the preset torque is reached during the tightening operation the handle will automatically release or "break" producing approximately 15 to 20 degrees of free travel. This release is distinct, easily detected by the mechanic, and indicates completed torquing action on the fastener.

Tightening Head End—When a fastener is tightened from the head end, some of the torque applied is absorbed in turning the bolt in the hole. The amount of torque absorbed will vary depending on the clearance in the hole and the alignment of the parts. For this reason torque values are specified for tightening fasteners on the nut end. However, in some instances it will be necessary to tighten the fastener from the head end. On these occasions the fastener should be tightened to the high limit of the torque value specified.

New Nuts—It is good practice in torquing, especially in torquing new bolts and nuts, to first tighten the fasterner to the desired torque and then loosen the nut or bolt by backing off approximately ½ a turn. Then retorque to the specified torque. This aids in cleaning and smoothing the threads and results in more accurate torque.

Aligning for Cotter Pins—When a nut is to be secured to a fastener with a cotter pin or wire, the nut should be tightened to the low limit of the torque specified and the hole aligned by a tightening operation. *Never loosen a castellated nut to obtain alignment.*

Thread Lubrication—Threads must be clean and free from nicks, burrs, paint, grease or oil to obtain the correct tension or pre-load in the bolt when it is tightened to the specified torque. However, there are some applications where lubrication or anti-seize compound is used on the threads. The maintenance manual should be consulted with regard to the torque value for lubricated threads when specified.

Damaged Threads—Studs with damaged threads should be replaced or the threads rechased; however, this is not always possible in field maintenance. To overcome the problem of properly torquing a nut on a stud where thread damage is present and therefore increases the rundown resistance of the nut, *add* the run-down resistance to the specified torque. The run-down resistance should be measured on the last rotation before the nut seats. For example, if 325 pound-inches of torque is specified for an application and the run-down resistance due to thread damage is 25 pound-inches, the nut should be torqued to 325 pound-inches, plus 25 pound-inches, or 350 pound-inches.

Check Pre-Torqued Nuts—Checking fasteners accurately to determine if they have been tightened to the specified torque value is not possible. A fastener that has been tightened to a specified torque requires approximately ten percent more torque than was originally applied to overcome friction and start the fastener turning. When there is doubt as to whether a fastener has been tightened to the correct torque, the fastener should be backed off from ½ to one full turn and retightened to the correct torque value. A torque wrench should not be used for the back-off operation.

Use of Attachments—Many torque wrench applications will require the use of attachments such as adapters and extensions to reach fasteners in places of limited accessibility or to position the torque wrench so that the dial is more easily read.

Concentric Attachments—The use of an attachment which operates concentrically with the drive square of the torque wrench presents no particular

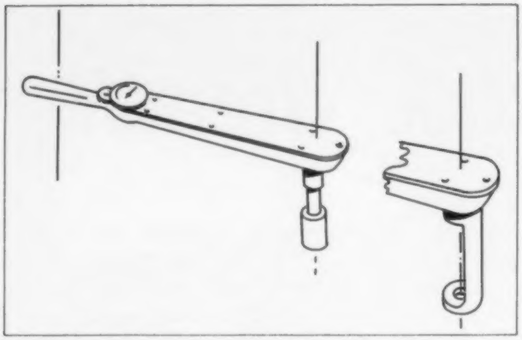


Fig 1—Concentric Torque Wrench Attachments

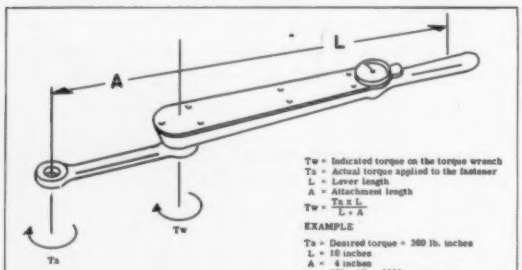


Fig 2—Torque Wrench Attachment—Extension

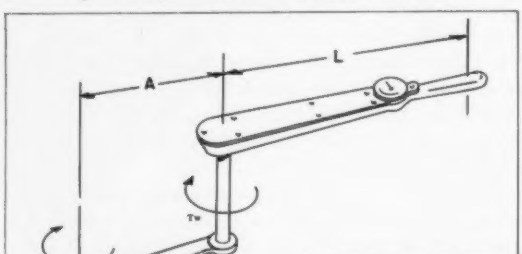


Fig 3—Torque Wrench Attachment—Offset Extension

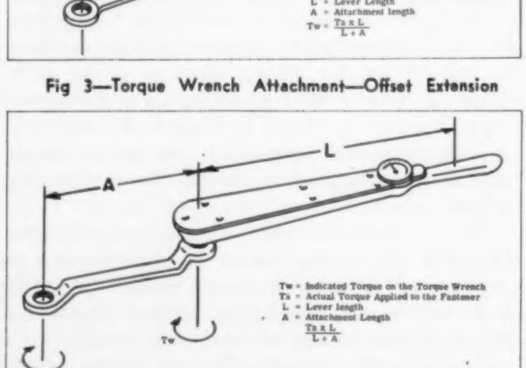


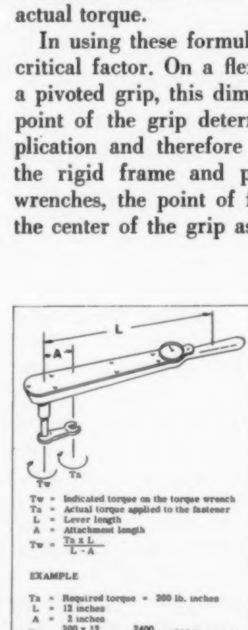
Fig 4—Torque Wrench Attachment—Offset Extension

problem, since the effective length of the wrench is not lengthened or shortened. The torque applied to the fastener will therefore be the torque indicated on the dial. Figure 1 illustrates typical attachments of this type. These attachments may also be used on the pre-set, sensory or audible type torque wrenches without affecting the torque setting.

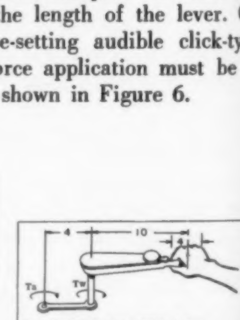
Nonconcentric Attachments—On some torque applications, an attachment will be used on the torque wrench that does not operate concentrically with the drive square. An attachment of this type has the effect of lengthening or shortening the lever length, and the torque value shown on the dial is not the torque that is applied to the fastener. When using these attachments, it is necessary to calculate the effect of the lever length to determine the correct torque reading. Figure 2 illustrates an attachment that adds to the lever length with the applicable formula for obtaining the correct torque reading. The same formula applies to the attachment illustrated in Figs. 3 and 4. In these cases of added lever length, the indicated torque is smaller than the actual torque.

Attachments when used as illustrated in Fig. 5, shorten the effective lever length. In these instances, the attachment length, "A," is subtracted in the formula and the indicated torque is greater than the actual torque.

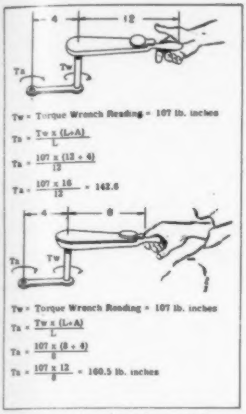
In using these formulae, the lever length "L" is a critical factor. On a flexible beam-type wrench with a pivoted grip, this dimension is fixed and the pivot point of the grip determines the point of force application and therefore the length of the lever. On the rigid frame and pre-setting audible click-type wrenches, the point of force application must be in the center of the grip as shown in Figure 6.



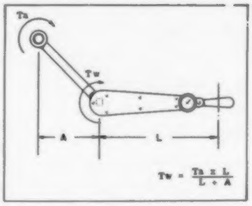
—Offset Reverse Extension
Fig 5



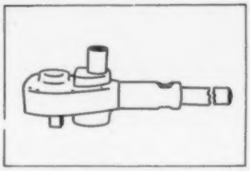
Proper Application of Force
When Using Extensions
Fig 6



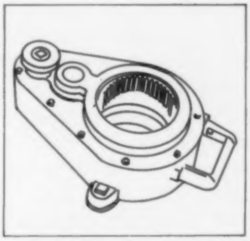
Improper Application of Force
Fig 7



Torque Wrench Attachment —Angle Extension
Fig 8



Torque Multiplier—General Use
Fig 9



Torque Multiplier for Hub Nuts
Fig 10

In Fig. 5-6, using the 10-inch lever length, 107 pound-inches of torque as read on the torque wrench, results in 150 lb-in of torque on the fastener when the force is applied correctly to the center of the grip.

If the force were applied to the torque wrench at the tip end or the root of the grip as shown in Fig. 7, at the same 107 pound-inch reading, the torque applied to the fastener would be 142.6 lb-in and 160.5 lb-in respectively.

Angle Attachments—Attachments will not always extend straight from the end of the torque wrench. In instances where the centerline of the adapter is not in line with the centerline of the torque wrench as illustrated in Fig. 8, the length of the adapter is not used. The effective length used to calculate the torque reading is the distance "A" in Fig. 8

Torque Multipliers—The direct application of torque to a fastener is limited by the force that can be applied by a man and by the length of the wrench. The force a man can apply to a lever varies to some extent but is approximately 100 lbs. With a wrench 30 inches long, the torque that can be applied is 100 x 30 or 3000 lb-in (250 lb-ft). Higher torques are possible with longer wrenches; however, there is a limit to the size of a wrench that can be used effectively by one man. Torque multipliers are used for the high torques such as those specified for engine thrust nuts, propeller, and helicopter rotor hub nuts. Figs. 9 and 10 illustrate typical torque multipliers. They are available in ratios from 3 to 1, to 11.1 to 1. Multipliers must be anchored or secured to a structure relative to the fastener being tightened, or be fitted with a reaction bar to prevent the multiplier from turning. For this reason, their use is usually restricted to special applications. When using a torque multiplier, the torque to be applied with the torque wrench is determined by dividing the specified torque for the fastener by the multiplier ratio; for example:

If the torque specified for the fastener is 3000 lb-ft and a torque multiplier with an 11.1 to 1 ratio is going to be used, then 3000 ÷ 11.1 or 270 lb-ft is the torque applied by the torque wrench. In this case a 350 lb-ft capacity torque wrench or a wrench up to 900 lb-ft capacity would be used to apply 270 lb-ft of torque to the input of the torque multiplier. In this range of torque wrenches, the applied torque is between the desired 30 to 80 percent range.

Care of Torque Wrenches

Storage—A torque wrench is a precision measuring tool and when handled and used with reasonable care will remain accurate and serviceable for a considerable period of time. Torque wrenches should never be carelessly tossed among other tools. They should be stowed in a clean, dry place where they will not be subjected to shock or damage.

Handling—A torque wrench should never be dropped to the floor. If this does happen, the wrench should be checked for accuracy before being used again.

Alterations—The frame is the measuring element on a flexible beam-type wrench. Any alteration to this frame will seriously affect the accuracy of the wrench. Do not file, mark, or etch the beam in any way.

Overloading—A torque wrench should be used with care to avoid loading the wrench in excess of its capacity. Overloading a torque wrench can result in permanently deforming the torque sensing element

and damaging the wrench.

Testing

Reason for Testing—A torque wrench is subject to wear and other factors which can be detrimental to the accuracy of the tool. Periodic testing in accordance with applicable directives is essential to ensure continued accuracy. Torque wrench testers are provided through Allowance Lists.

Types and Operating Principles of Testers—Several different types of torque wrench testers are manufactured and to ensure their proper use, some understanding of their operating principles is desirable.

A torque wrench tester consists of a force resisting element to absorb the load applied by the tool and a dial or scale to indicate the magnitude of the applied load in torque units. A maximum reading pointer is provided that remains at the point of maximum applied torque and holds the reading when the load is released until reset to zero by the operator.

The force resisting element may be a weight, a steel spring, a torsion bar, or strain gage load cells. The movement or deflection of the force resisting element resulting from the application of the load applied by a torque wrench is relatively small and must be magnified in order to indicate the small variations in the amount of the applied load. Magnification is accomplished on mechanical type testers by a gear segment and pinion or a mechanical linkage. Other types of testers use optical magnification or electronic amplifiers.

How a Tester is Used—A torque wrench tester is a precision measuring instrument and reasonable care is required to obtain accurate readings. A load in excess of the capacity should never be applied to a torque wrench tester as this may damage the instrument and destroy the accuracy.

A tester for manual torque wrenches should never be used for checking a powered torque tool such as a nutrunner or impact wrench.

To test a torque wrench, the wrench is applied to the tester in the same manner as it would be used on a nut or bolt. A socket or adapter is used to connect the drive tang of the wrench to the input of the tester. Torque wrenches should be tested for accuracy at approximately the 15, 40, 65 and 90 percent points of the range. A minimum of three readings should be taken at each point.

When testing a flexible beam or dial type torque wrench, a predetermined torque, indicated by the torque wrench dial or scale is applied to the torque wrench tester. The load is then relieved and the torque indicated by the maximum reading pointer on the tester is noted and compared with the torque value applied by the torque wrench.

When testing an audible sensory type torque wrench, the wrench is preset to the desired torque and applied to the torque wrench tester. The reading on the tester is observed as the torque is applied. Care must be exercised to note the torque indicated when the wrench clicks or "breaks" since the snap action of the wrench may cause the maximum reading pointer to over-ride and give a false indication of the applied torque.

Accuracy Limits—Accuracy limits for torque wrenches are established by Bureau of Naval Weapons Instructions and Specifications. MIL-T-4304 and CG-W-00686 are typical torque wrench specifications. Wrenches that do not conform to the prescribed accuracy must be removed from service and turned in for recalibration. *Unauthorized personnel should not attempt to calibrate, repair or alter torque wrenches.*

—Ref: NavWeps 17-1-108, dtd 15 May 1966

Spilled Gas Creates Holocaust

UNLOADING of a seven-compartment semitrailer containing 7740 gallons of gasoline was proceeding normally when suddenly the feed hose slipped from its coupling, spraying gasoline over the truck and warehouse. Gasoline vapors were pulled into the breather of the truck's diesel engine, causing the engine to accelerate to a runaway condition. This in turn caused flames at the exhaust, which ignited vapors from the escaping gasoline.

The gasoline ignited 5 seconds after hose failure. About 2000 gallons of gasoline flowed from the hose and burned, destroying the warehouse, the tractor and the forward half of the trailer. The driver was sprayed with gasoline before he could escape, and received third-degree burns.

—National Safety News

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Notes and Comments on Maintenance

Device for Detecting Free Water in Aviation Fuels

A simple, low-cost detector that can be used on all aviation ships and airstations for accurately measuring trace quantities of undissolved water in aviation fuels has been developed by the Aeronautical Engine Laboratory (AEL), of the Naval Air Engineering Center. The device, called a Free Water in Fuel Detector, has been field tested and found to be very accurate. It is designed for use in conjunction with the Contaminated Fuel Detector, also developed by AEL, which is being used for detecting and measuring small quantities of solid contaminants dispersed in fuels.

Free water in even small amounts, less than 30 parts per million, can cause major corrosion damage in aircraft integral wing tanks, can promote and accelerate filter–plugging microbiological growths, and can deactivate delicate engine parts where tolerances are close.

The AEL Free Water Detector utilizes a 47mm absorbent pad sensitized with a chemical that will fluoresce under ultra-violet light after reaction with water. A 500 mil. sample of fuel is passed through this pad. If any free water is present in the fuel sample, the water droplets react with the impregnated chemical, resulting in fluorescence that can be viewed readily under ultra-violet light.

The test pad is then removed from the sample holder and placed in a movable slide that can be inserted into a small black box containing a set of standards. An ultraviolet light is mounted directly above both the standards and the slide to provide maximum fluorescence from both. The standards currently in use represent 0, 5, 10, and 20 parts per million of free water in fuel. The slide containing the test pad is moved across the row of standards and the free water content is estimated by matching the fluorescence with the closest standard. The Free Water Detector has been tested thoroughly by all of the services and in commercial laboratories. It works well with all aircraft fuels and is not affected by any known fuel additives. Extensive field tests have been carried out by both fleet and shore units and in pipelines. All tests indicate that the device is ready for general Navy use.

Procurement of the Free Water Detector has been initiated for all naval air activities ashore and afloat. It is expected that this will become an extremely useful tool in combating a major problem of the jet-age, fuel contamination.

—*"NavWeps Bulletin"*

No Red O-Rings in T58 Fuel System

Samples of red O-rings recently received from T-58 using activities were laboratory tested and the tests showed them to be manufactured of material identified as dimethyl-siloxane elastomer. This material was *not* compatible with JP-4 or JP-5 fuel. In fact, the material disintegrated in JP-5 (confirming a prior field report).

Do not use red O-rings as alternatives for the specified fuel system seals in T-58 engines.

—*GE "Service News"*

FOD Prevention

Part of Competency

"There's an acquired skill involved in making tool counts, proper checks in seeing that everything is in top shape before takeoff, even in picking up loose junk. It's all part of being a competent mechanic. Even a good man has to keep working at it."

From the Floor

Minutes of a recent patrol squadron's enlisted safety committee meeting noted that the following safety violations had been repeatedly observed on numerous occasions:

1) Personnel applying and removing external power prior to checking the status of switches inside the aircraft.

2) Aircraft electronics equipment not being secured prior to removal or application of external power.

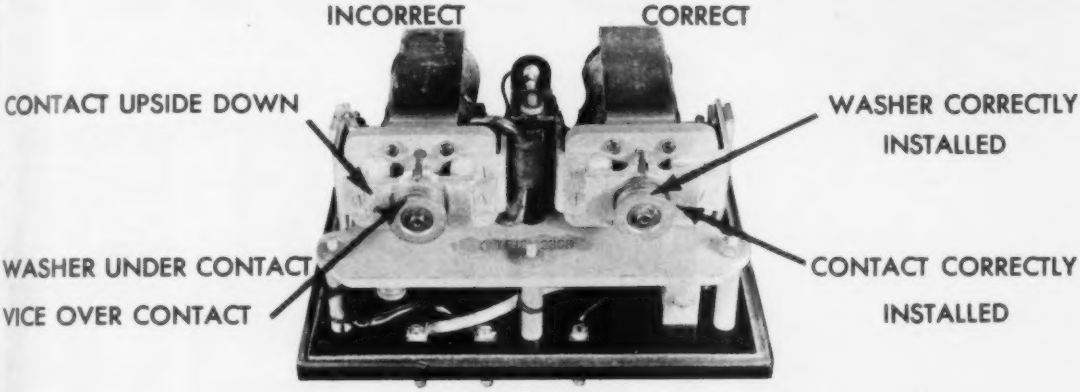
3) Personnel smoking on the hangar deck and in passageways.

4) Aircraft boarding ladder safety straps not being used.

5) Personnel walking through propeller arcs.

Proper supervisory responsibility must be maintained to prevent these occurrences, any of which could result in damage to equipment and/or injury to personnel. All shops will continue educating their personnel accordingly. All personnel are enjoined to take immediate corrective action whenever observing safety violations.

Murphy's Law*



Neptune Murphy

WHILE troubleshooting an electrical gripe on the No. 4 d.c. generator on an SP-2H, it was determined that one of the contactors was faulty. A repaired contactor received from the local AMD rotable pool was installed but this part did not remedy the malfunction. Because the contactor was an *RFI* item from AMD, the night check crew looked elsewhere for the cause of the malfunction. They did not locate the trouble that night, so it was passed to the day shift who worked on the problem until noon.

The Quality Control Inspector was called in to assist and once again the trouble was traced to the newly installed contactor. Upon removal of the suspect assembly, it was opened and inspection revealed that one of the main contactors had a set of *contacts installed upside down*. The spacers which were supposed to be on top of the contacts were now installed under them preventing the contacts from fully closing by at least ¼ inch. Note left contactor of photo above. Correct reassembly of the parts and reinstallation corrected the problem. Had the contacts been installed properly when the unit was repaired the aircraft would have been up 22 hours earlier. *Contributed by AE1 Arthur R. Whittman, Quality Control, Patrol Squadron SEVEN.*

Big Boat Murphy

AN SP-5B was launched for a post-check test flight. Upon casting off and clearing the buoy, the pilot attempted to extend the port hydroflap to commence a port turn. The aircraft responded by making a starboard turn and when the pilot released foot pressure, the hydroflap failed to close, remaining in the fully extended position. Prompt and judicious use of differential and reverse power kept the aircraft from striking the ramp.

Cross-connected cannon plugs, resulted in the following: With hydroflap taxi switch ON, instead of unlatching the hydroflaps, power was directed to the right hydroflap control valve. When the port pedal was repressed the hydroflaps unlatched. With power already available to the right hydroflap control valve through the taxi switch the right hydroflap extended and remained extended.

To check for the possibility of this Murphy, pilots have been instructed to test the hydroflaps individually—instead of simultaneously—before going over the side.—*Contributed by Safety Officer R. N. Atkinson, VP-48 Det.*

* If an aircraft part can be installed incorrectly, someone will install it that way!

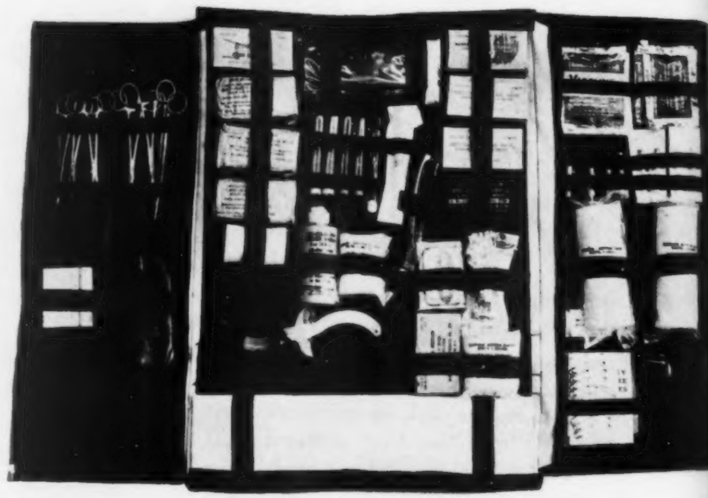
Letters

Crash Backpack

MCAS, Cherry Point—We recently fabricated a crash backpack which has several advantages over the traditional doctor's bag. See photo below.

Because both hands are left free while wearing it, it is handier trekking through the brush or riding up and down a helo rescue seat. It unzips and the flaps fold back so that emergency gear is only one layer deep and can easily be found. See photo, right.

We pack only equipment likely to be needed for acute care; the loaded pack weighs less than 10 pounds.



. . . with emergency gear only one layer deep.

Doctor's backpack . . .

The pistol belt holds a canteen on one side and a canvas bag containing a liter of saline with I.V. set on the other. A flashlight would be another handy item to carry on the belt.

The unit is kept in our crash ambulance and can easily be put on enroute to the flight line. We don't keep a doctor on the flight line but answer crash or other emergency calls from the hospital in a special "crash ambulance" equipped with UHF.

C. G. AMBROSE, SGT. USMC
J. E. DOWNING, LT MC

• **Good Show!**

APPROACH welcomes letters from its readers. All letters should be signed though names will be withheld on request.
Address: APPROACH Editor, U. S. Naval Aviation Safety Center, NAS Norfolk, Va, 23511. Views expressed are those of the writers and do not imply endorsement by the U. S. Naval Aviation Safety Center.

Need to Use OJT

NAS Norfolk—Your article "NC-5 Plug-in Warning Devices" mentioned that "a more positive device is desired." What could be more positive than two licensed and qualified operators?

Licensed and qualified as required by ComNavAirLantInst 3500.36A standards will insure correct techniques and proper habits are developed in the operation of the NC-5. Training material (approved by CNO, Oct 63) used by ASE detachments, AMDs and ships clearly state "there should always be two operators, driver and electrical operator." NavWeps 00-80T-96, page 1-6, "Servicing with the mobile electric power plant is always a two-man operation. . . ."

Licensed and qualified operators are my positive devices that can prevent hapless experiences.

J. PACE, JR., AEC
NAMTRADET 3032 (ASE)

• **You're right but it happens nevertheless. Why? See the next letter.**

Letter of Apology

From: MUGS, A. D., Equipment Handler, USN
To: UNITED STATES NAVY
Subj: Apology; letter of
Ref: Guilt; feeling of

1. For those of you who don't know me or my reputation, let me introduce myself. I was born out of the first exhaust stroke of the internal combustion engine and have spent most of my life on the line. Or more specifically; I have, at one time or another, belonged to the Line Division of every squadron in the United States Navy. I have been at the wheel of every type vehicle. I have pushed every type aircraft and moved every work stand the Navy has owned. I might also add that I have taken responsibility for every incident and accident involving aircraft and rolling stock. You see, I am always around when other men are not willing to assume responsibility for their actions. I have cost the Navy millions each year and put an untold number of aircraft and good men out of commission throughout my years on the line.

2. But now let me tell you the side of the story which has never been published. I am an old man who had held tremendous pride in his work through the years. You might say, I have been proud to a fault, in that I have always been willing to accept the responsibility for the actions of those men who were not man enough to shoulder their own responsibilities. I have always borne the brunt of accusations against me without defending myself with the standard "I didn't do it," or "It didn't happen on my watch." I have always been proud of myself and my actions and now it is time to relate the nature of my apology.

3. My apology is that—

I am sorry for all the times I neglected to instruct men in the proper techniques of operating vehicles.

I am sorry for all the times I failed to instruct men in the art of properly securing an aircraft or a workstand.

I am sorry for all the planes which have been pushed over the side because the pushers were not properly instructed by me.

In general, I am sorry for all the mishaps which have occurred on the line during my long tour in the Navy.

4. But age has diminished my pride and increased my wisdom with the realization that I should not have been so quick to hang my head and accept responsibility for the actions of others. My pride still lies in the fact that I have always accepted responsibility for my own actions.

5. *My warning to all and my charge to you is this: I charge you with accepting your responsibilities and making yourselves worthy of the confidence bestowed upon you every time you are allowed to perform work in my United States Navy.*

A. D. MUGS

• **Please read the next letter.**

Safe Driving Points

NPC, Wash. D.C.—In reference to photos and comments on "Yellow Gear" in the August issue, and the endless flow of words, notices, instructions seen the last 21 years on this subject, the following is offered for consideration.

I've often heard the comment, "The only thing a (Navy) driver's license will get you is trouble." There is much truth in this. Many good men do not get licenses and if they do, they avoid driving because it certainly does increase their chances of getting into trouble. I know of no case where a driver of yellow gear was ever commended even though he may have driven for a full tour in a squadron without scratching paint. Since driving yellow gear does require skill, common sense, and a high degree of alertness, the Navy should recognize the licensed individual. I propose that each man who is licensed and maintains a safe record should be credited a minimum of 2 points on his multiple score for advancement in rating. Another method would be to give an individual 1 point per year, and as long as a safe driving record is maintained that the points be cumulative to a maximum of 5. Points now are credited in this manner for Good Conduct Medals. If his license was pulled he would lose all points.

All too often our yellow gear drivers are strikers who haven't been able to do their primary job well. The officers who fly our aircraft are the best, and it should follow that we must also attract the best men to handle the ground equipment. However, to attract the best men, we have to offer them something.

Years ago I saw a tractor driver doing about 20 mph, attempt to go between two TBM aircraft which were parked with wings folded. He destroyed a wing on each one. Last year prior to leaving an RA-3B squadron, I saw an NC-5 driver drive off without unplugging. Flight safety has improved immeasurably in the last 20 years, but this ground equipment problem seems to be worse than ever, mostly because we have so much expensive support gear now; nevertheless, we still select drivers like we were selecting mess cooks, and we follow through by giving them about the same recognition a mess cook gets.

C. L. LARSON, LT

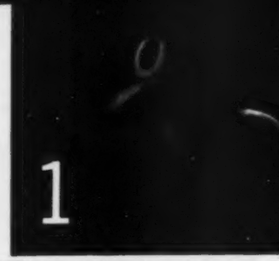
• Makes good sense. Now an airman apprentice must pass Practical Factors for Airman. For example, NavPers 760 (AN) states: "Observe standard operating techniques and handling procedures when using mobile equipment around aircraft . . . connect and disconnect external power cables for starting and servicing aircraft."

But after he makes Airman he must qualify further by licensing for a particular type vehicle. There are many types so continuous training is necessary to qualify in type. Unless there are incentives, as you mention, few people will attempt to qualify or retain their qualifications. While Practical Factor Records have a provision for adding requirements on the local level it would be unfair if one unit required driver proficiency and another did not. Standardization, Navywide, would be necessary. Adoption of your idea appears to be a step in the right direction if there is to be any significant improvement in this area. The floor is open for further comments.

Vol 12 **approach** No 4

Our product is safety, our process is education and our profit is measured in the preservation of lives and equipment and increased mission readiness.

Contents



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Cover painting: P-3A on station in Vietnam by Chet Engle, Courtesy Lockheed California.

Pages 28, 29: Photo by Ed Holm, Courtesy Naval Institute Proceedings

Pages 34-36, 38, Photos and diagram courtesy Naval Air Engineering Center, Philadelphia.

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Mental Attitude, Self-Discipline and You!

"Vigilance is the price of safety" is as true as ever. But is it the whole truth?

Several AARs, recently reviewed, emphasize that meticulous compliance with instructions is another important part of the price one must pay. Each was the subject of a violation of a written instruction which was disregarded.

Flight instructions (i.e. NATOPS, etc.) are there for a purpose, and safety is usually the main consideration. They represent conclusions reached in the light of all available knowledge and experience. Also, they are drawn up in conditions that will not be available in the cockpit in an emergency: e.g., time to consider alternatives, time to consult others, time to think.

In aviation there is often more than one way of performing a given operation. But the only one that is authorized is the one that which is laid down in the applicable manual. Make sure you know it. Apply it meticulously.

Is it not then a question of mental attitude? That kind of attitude which makes people comply with ALL rules as a matter of self discipline? Self discipline then as well as vigilance is the real price of safety in the air.

—Adapted from BOAC

Contributed by LCDR J.R. Priestly, ASO, HC-4 Det. 1